# POWER

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## Lifting the Burden

JUDGE THEODORE G. RISLEY, in an address at the dinner of the M. E. B. A. in Washington recently, said that all the workers of all the world, driven like slaves from sunrise to sunset, could not do the work that is performed by machinery in the United States alone.

In fifty years the amount of power available to each wage worker in the mills and factories of this country has been multiplied by five, and by the improvement in the processes of production and distribution of power the muscular labor of the small artisan, the farmer and even the housekeeper has been materially reduced.

By reason of this reduction in the time and manpower required per unit of production and the possibility of the manufacture in quantities, of articles which it would be otherwise impossible to produce at all—the wage earner of today is enabled to exchange his day's work for more of the comforts and conveniences and refinements of life than the income of a king or a Croesus would have purchased centuries ago.

And it is capable of demonstration that as wages go up, and, with a just division of the products of labor, the purchasing power of the day's work would go up in proportion to the amount of power employed per workman and the efficiency with which he uses it.

The history of the introduction of labor-saving methods and machinery has always been one of opposition from the very people whose labor they were designed to lighten. And the realization of their greatest collective saving has been hindered by the "conscientious" withholding of efficiency by those upon whose best and most efficient use of them the consumers of their products are dependent for its most complete and widely extended benefit.

No considerable change can be made without disturbing somebody in the niche into which he has settled and the process that he is pursuing in earning, or getting, his living.

Elihu Root says, "It is no impeachment of a man's honesty, his integrity, that he thinks the methods that he is familiar with and in which he is engaged are all right. But you cannot make any improvement in this world without overriding the satisfaction that men have in the things as they are, and of which they are a contented and satisfied part."

With better intelligence, greater breadth of view and clarity of thinking on the part of the worker and his leaders, this attitude is changing.

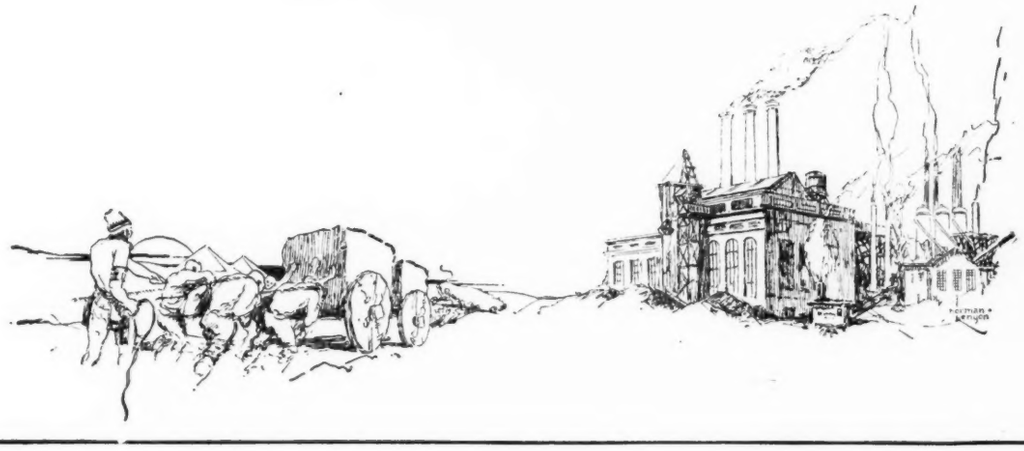
The man who makes a costly machine turn out only half of its capacity or who wastes material, is beginning to realize that he is making its product cost more to his fellow workmen and to himself, and he needs only to be convinced that greater care and efficiency upon his part, and the cheapening of production by improved machinery and methods, will inure to the benefit of himself and his kind, to welcome and himself suggest and assist in the adoption of such improvements and the development of their full possibilities.

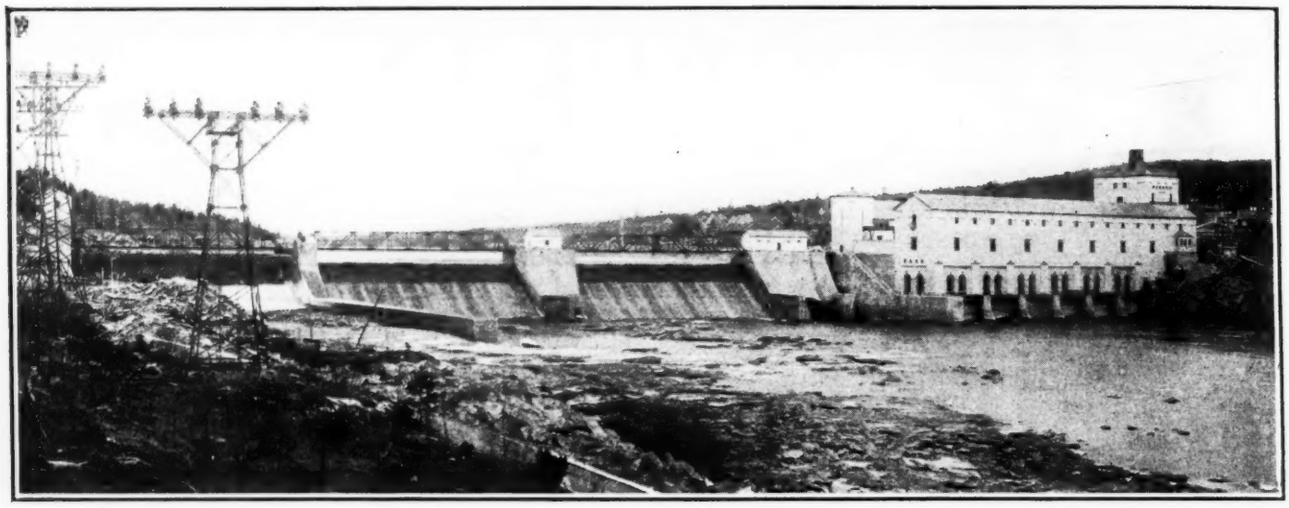
What is needed now is to establish it as a fact that the benefits of such advances do go to the consumer and not to the inordinate enhancement of profits.

This involves the direct application of Mr. Root's remark to the employer and manufacturer.

Having made this a fact and convinced the workingman of its establishment, there will be no more trouble about the introduction and the most advantageous use of labor-saving machinery.

J. R. Low





# Turbines in Raanaasfoss Power Station*

By HALLGRIM THORESEN
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*This plant contains six double-runner horizontal-shaft 12,000-horsepower turbines operating under a head varying from 31 to 46 feet. The turbines are set in open flumes and two different European designs are used.*

RAANAASFOSS power station belongs to the county of Akershus, Norway. It is situated at Raanaasfoss Falls on the Glommen River, about 27 miles northwest from Christiania. The power station (see headpiece) forms a part of the dam, which is about 900 ft. long, built across the river and creates a reservoir approximately 3.2 square miles in area.

### Determination of Size and Type of Turbines

The minimum flow at the site of the development is 7,700 cu.ft.-sec. Since by regulating the lakes above, it would be possible to bring the minimum winter flow up to about 11,000 cu.ft.-sec. and as there was every probability that such regulation would be carried out in the near future, it was decided that a minimum flow of 9,500 cu.ft.-sec. could be taken as the basis for determining the plant to be installed. In making this decision due consideration was given to the fact that, owing to the large reservoir formed by the dam, sufficient storage was available to take care of the daily variation in the power delivered, and the size of the machines was therefore based on the possibility of having an available flow of 12,000 cu.ft.-sec. (9,500 cu.ft. plus about 25 per cent).

In winter the head is about 43.3 ft., but in flood periods this may be reduced to about 31 ft., owing to the rise in tailwater level. By blasting away the Sundfoss falls below the power station, the head in winter could be increased to 46 feet.

On this basis and keeping in mind the desirable size of the units from a manufacturing point of view, it was decided to divide the 12,000 cu.ft.-sec. among four units of 3,000 cu.ft. each. In order, however, to obtain the same output during flood periods when the head is reduced, and with a view to the possibility of delivering flood power in summer and also in order to have some reserve, it was decided that six units should be installed, each of which would utilize 3,150 cu.ft.-sec. at a head of 40 feet.

With four machines running, this plant can produce 51,000 hp. using 12,000 cu.ft.-sec. at a 43.3-ft. head. This output can be maintained by using five machines if the head decreases to 36 ft., which would be the case with a flow of about 35,000 cu.ft.-sec. in the river. When there is a greater flow than 35,000 cu.ft.-sec. and a corresponding reduction in head, all six units may be run if the same total output is desired. As the maximum flood exists only for short periods and always occurs in seasons when the normal power requirements are smaller than in winter, it has not been found necessary to provide spare machines for the delivery of full power at these times.

### Why Double-Runner Horizontal Turbines Were Chosen

Several plans for vertical- as well as horizontal-shaft turbines were considered, but double-runner horizontal turbines were chosen. These were designed for 12,000 hp. at 107 r.p.m. for a net head of 40 ft. This arrangement was not only the least expensive, but also required the shortest power station, which was important, as the available space for the station was limited.

Double-runner horizontal turbines in open flumes with the intake from the forebay in an axial direction from one end and the draft tube extending out under the generator room, also in the axial direction, Fig. 5, gave suitable dimensions and comparatively simple construction. The arrangement has long been used for smaller sizes, but has recently been developed for large turbines also, especially in Sweden.

Below the intake ends of all the turbines there is an inspection duct *D*, Figs. 5 and 6, from which there is access to the bearings on the upstream end of the turbines. The governors are placed in the generator

*Based on the official report on this installation, prepared by the Akershus Elektricitetsverk.

room near the upstream wall. A duct *C* runs under all the governors in which the oil pipes are laid.

Of the six turbines installed, what are know as Nos. 1, 2 and 3 were supplied by Aktiebolaget Karlstads Mekaniska Verkstad, Verkstaden Kristinehamn, Sweden, associated with Boving & Co., Ltd., London; Nos. 4, 5 and 6 were supplied by J. M. Voith, Heidenheim, Germany. Both firms were given a free hand as to the type of regulation system and the position of the bearings. It was specified that both types should suit the inspection duct and the pipe duct and also that the appearance of the machinery in the generator room should be as nearly similar as possible. The weights of the machines delivered were surprisingly similar. The Verkstaden's turbines with governors weigh 234 tons each, and Voith's, 226 tons.

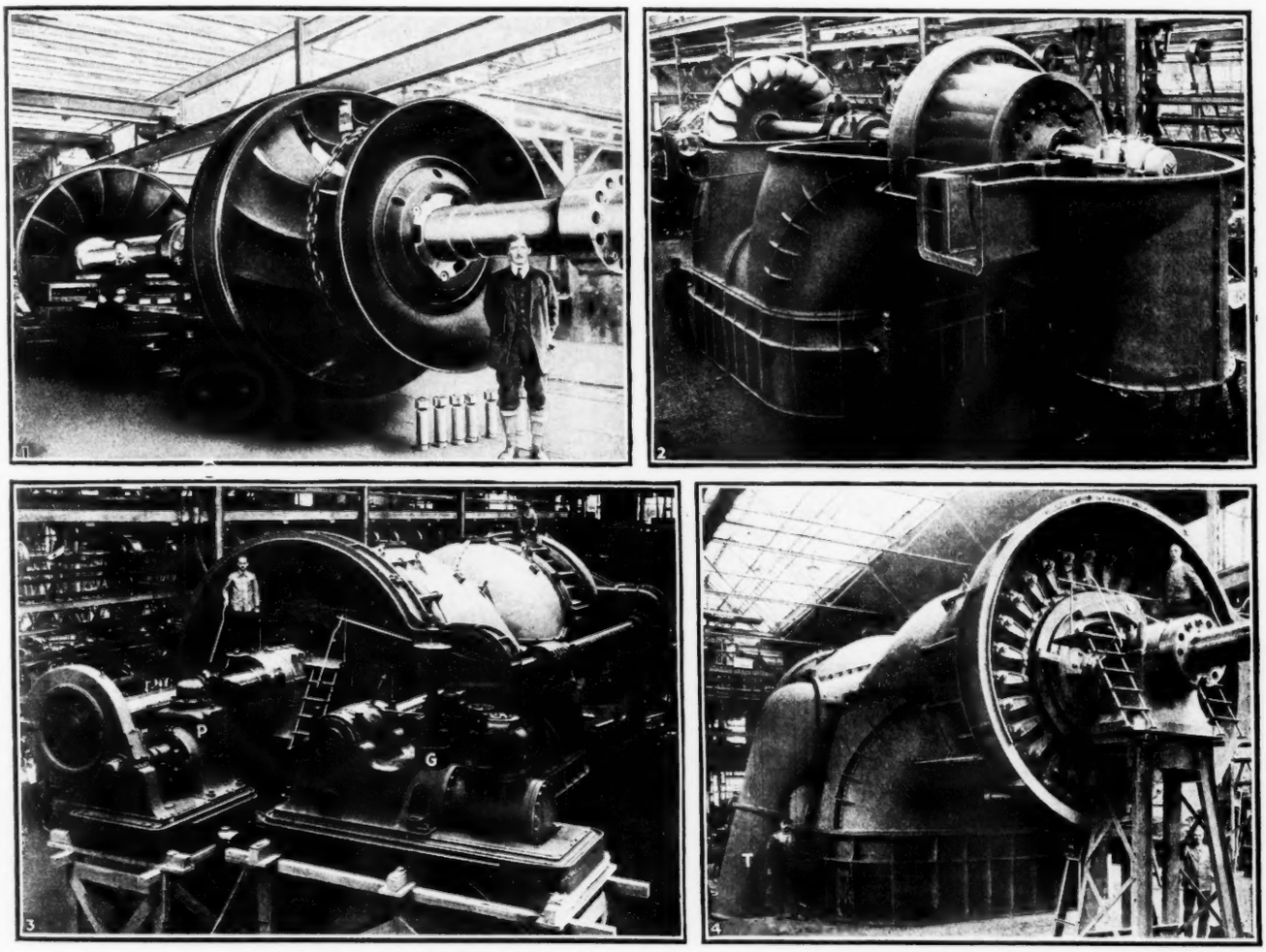
All turbines were ordered for an output of 12,000 hp. for a net head of 40 ft. at 107 r.p.m. and a discharge of about 3,200 cu.ft. The highest guaranteed efficiency was 85 per cent at about 10,500-hp. load. With heads of 43.3 and 46 ft. full-load ratings would be 13,400 and 14,600 hp. respectively and about 3,500 cu.ft.-sec. discharge.

In order to obtain the best possible type of runner and in view of the terms of the contract, both firms carried out a number of experiments in their testing stations with model runners of 25.5 to 27.5 in. diameter. These runners were tested in half draft chests of the same shape as that which would be used in the installation. These tests were supervised by the purchaser, who had the right to demand the continuance of the trials and for extra payments even after results had been obtained satisfying the conditions of the contract.

### Description of Turbines Nos. 1, 2 and 3

**Fig. 5** shows the general construction of units Nos. 1, 2 and 3; Fig. 1 is one of the runners. The runners are made with buckets of ship-quality plate steel cast into a band and a hub of the best Swedish cast steel. They have a maximum diameter of 11 ft. Since these runners were built, the Kristinehamn works have made runners of this type with a maximum diameter of 16.5 ft. for the Russian government, but in this case the buckets are cast into cast-iron bands and hubs. These are the largest runners with plate buckets that have been built.

Steel plate was chosen for the runner buckets mainly because this material has been found to be more durable than cast steel, which is an important factor in high-speed turbines. Furthermore, steel plate has a smoother surface, which is important from the efficiency point of view.




*Figs. 1 to 4—Turbines in various stages of erection in shops*

Fig. 1—Runners for turbines Nos. 1 to 3. Figs. 3 to 4—Views of turbines Nos. 4 to 6. The governor pressure oil pump *P*, Fig. 3, is driven by herringbone gears from the mainshaft. The governing and regulating equipment is located at *G*. Access is had to the middle bearing on the runner shaft through passage *T*, Fig. 4.

The draft tubes are of the type previously used at the Untra power station, which was designed after exhaustive tests in Verkstaden's testing station. These tests have shown the design of the draft tube to be of equal importance to that of runner, since by making even very small alterations in the shape of the draft tube, the efficiency may be changed 5 to 6 per cent.

The turbine shaft's total length is 58.5 ft., and it is is had through a vertical shaft from the inspection duct *D* running under the ends of all the turbines.

The regulating mechanism is in the flume, but the guide-vane pins as well as the regulating ring can be lubricated from the machine room and inspection chamber while the turbine is running. For these turbines inside regulation mechanism is much simpler than outside regulation and has proved to be reliable and durable when it can, as in this case, be lubricated while the turbine is in operation. For instance, it may be mentioned that the large 12,500-hp. turbines of the Swedish government power station at Trollhattan, which have been in practically constant operation for about 13 years, have experienced so little wear in the regulating parts that not a single bushing has had to be replaced.

Each runner has 20 cast-steel guide vanes, any one of which can be removed without disturbing the other parts of the equipment. The regulating ring is mounted on rollers which are fitted into an annular space in the regulating ring. To protect and lubricate the rollers, this space is filled with grease which can be forced in from the generator room and inspection chamber.

The governor shaft *G*, Fig. 5, for operating the regulating rings, is

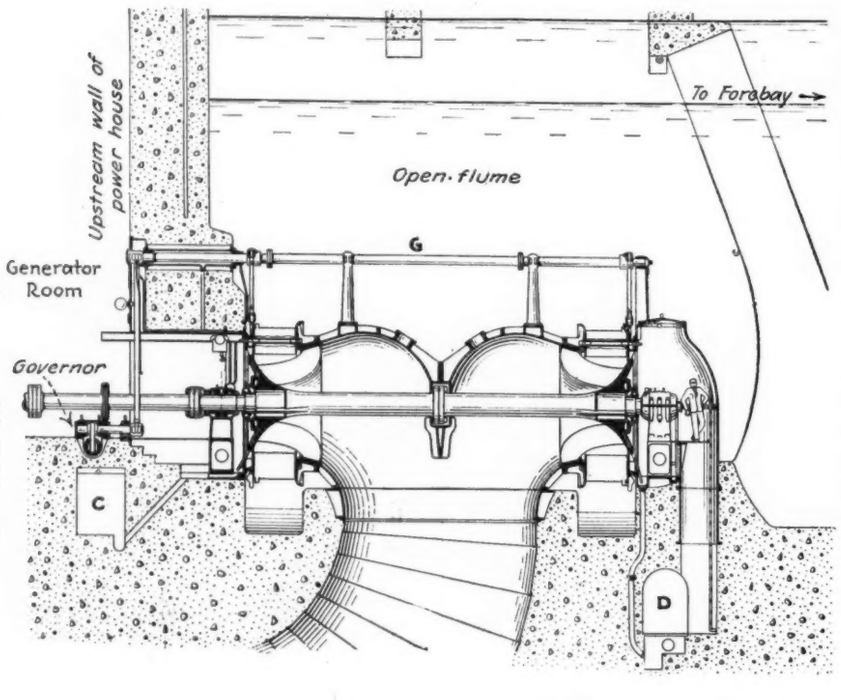



*Fig. 5 (above)—Section through turbine No. 1*

This is the type of construction used in units No. 1 to 3. Turbines set in open flumes and access is had to the upstream bearing from tunnel *D* in the concrete foundation. The runner shaft, which is hollow, is in two sections having a diameter of 24.6 in. and is supported in bearings 40 ft. apart.

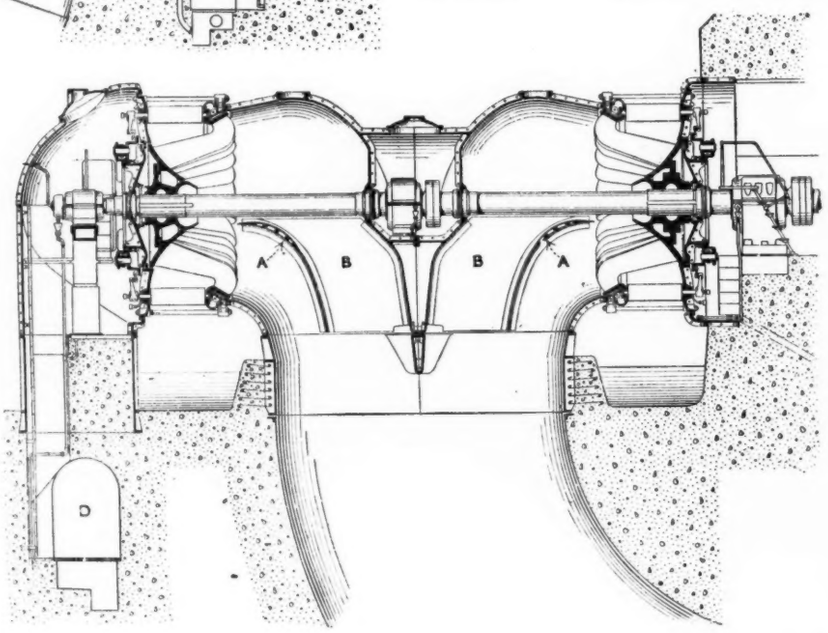



*Fig. 6 (right)—Section through turbine No. 4; units 5 and 6 are of similar construction*

In these units the shaft is supported at the middle, by a bearing in the draft-tube chamber. This bearing is surrounded by a water-tight cast-iron chamber and is accessible through an inclined entrance tunnel leading to a duct in the concrete foundation. The draft tube leading from each runner is divided into four sections by baffles *A* and *B*.

divided into three parts which are connected by means of forged flanged couplings. Of these one is in the middle of the draft casing. The shaft is hollow and is supported on two bearings 40 ft. apart. As there is no bearing in the draft casing, the shaft had to be of large diameter (24.6 in.) in order to prevent excessive deflections.

The bearing shells have spherical seats. The thrust is hydraulically balanced so that the bearings could be made plain—that is, without collars. The upstream bearing on each turbine is in a chamber to which access above the center of the turbine. This is connected with both regulating rings by means of levers and links. In order to eliminate the effects of torsion in this shaft, one crank is mounted a little in advance of the other so that when shutting down, both sets of guide vanes will be properly closed. Owing to this and good workmanship the closing of the vanes is so complete that the turbine stops turning in a comparatively short time without using a brake.

To improve the flow of water to the lower guide vanes, the bottom of the flume under these vanes is

made spiral in shape. This formation had been used at the Untra installation with good results.

To facilitate synchronizing and dividing the load between the individual machines, the governors are provided with electric speed adjustment in the usual way. *A* and *B*, Fig. 8, show the result of the governor test. In these tests the load was thrown on and off by means of the oil switch.

### Description of Turbines Nos. 4, 5 and 6

Turbines Nos. 4, 5 and 6 are of the twin horizontal-shaft type the same as units Nos. 1, 2 and 3. Their large size is apparent from Figs. 2 to 4, bearing in mind that the over-all height from the bottom of the base ring to the highest point on the turbine is 20.5 ft. and the total over-all length, 43.7 ft. As far as discharge capacity is concerned, a maximum of 3,500 cu.ft.-sec. at full load and 46 ft. head, they are the largest that have been constructed in Germany.

The runners, which are 7 ft. 6 in. in diameter at the hub and 10 ft. 11 in. at the discharge, have plate-steel buckets 0.67 in. thick, cast into cast-steel hub and band. The runner hubs are bolted to flanged hubs keyed on the mainshaft. The hubs are shaped to form a good passage for the water at the discharge end, and the opposite side is provided with annular grooves and tongues entering with small clearance into similar recessed seal rings on the cover plate. Thus the flow and pressure of the water entering the compartment behind stuffing boxes is appreciably checked. Slots in the hubs permit the water behind the runner to discharge into the draft chest, thereby reducing pressure and thrust on the runner.

The guide vanes are steel castings 41.5 in. wide, with their operating mechanism outside the water space, accessible for inspection and lubrication. An arrangement patented by Voith is used to facilitate the removal of each guide vane without dismantling other parts of the unit.

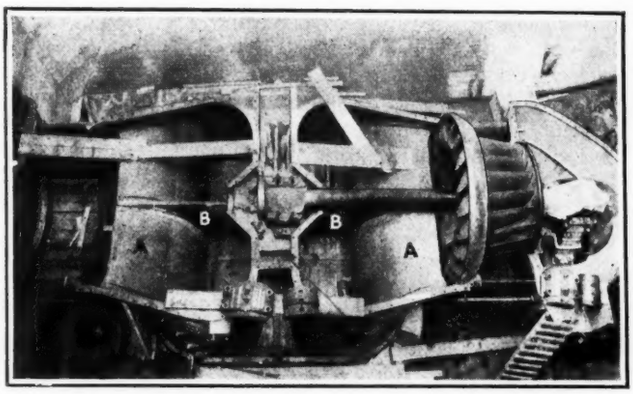



*Fig. 7—Baffles in draft tubes of units 4 to 6 shown at A and B*

The mainshaft, which has a total length of 50 ft., a maximum diameter of 18⅝ in. and 10⅞ in. at the thrust bearing, is divided into three parts, two of which carry the runners. The bearings at the shaft guide ends are collar thrust bearings with cooling attachment for injecting water into the hollow shaft ends. The intermediate bearing is in the draft casing, which gives a distance between bearings of about 21.05 feet.

For the purpose of controlling the water stream motion, dividing guides plates *A* and *B*, Figs. 6 and 7, are placed in the draft-casing bend immediately below the shaft and riveted to the cast-iron walls. Each draft chest is split horizontally and vertically into four parts.

The intermediate bearing is surrounded by a water-tight cast-iron chamber, built into the draft casing and accessible through an inclined entrance tunnel *T*, Fig. 4, leading to a duct in the concrete foundation, which is connected with a common inspection duct *D*, Fig. 5, underneath all turbines. From this duct a vertical shaft leads to the thrust-bearing chamber on the upstream end of the turbines, so that all bearings and regulating parts are accessible to the attendant during operation. The guide-vane arms derive their motion from double arms on the regulating shaft.

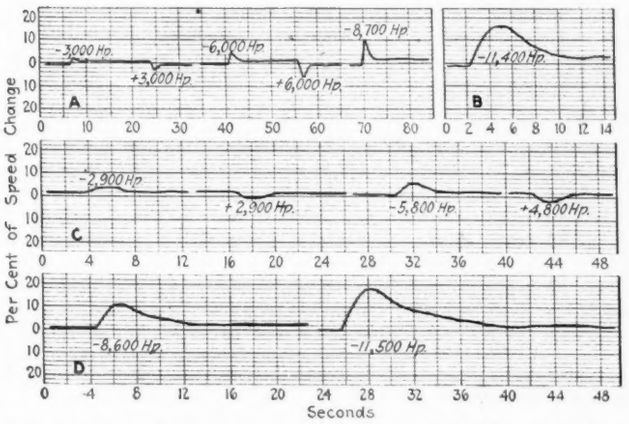



*Fig. 8—Speed-regulation curves for units Nos. 2 and 5*
Curves *A* and *B* are for No. 2 turbine and *C* and *D* for No. 5

The governor heads are belt-driven and are equipped for electric control from the switchboard for synchronizing and distributing the load between units. As can be seen from Fig. 3, one end bearing for the turbine-gate regulating shaft is mounted directly on the governing equipment shown at *G*, which combines the governor head pilot and regulating valves and servo-motor all in one unit. The accumulators are below the generator-room floor in a chamber on the side of the main duct underneath the governors, where also the oil piping is located.

Between full load and no load the governor is capable of maintaining the speed practically constant or if required a negative change can be obtained. The compensating gear includes also a device by which the maximum gate opening can be limited at any time. The purpose of this device is to prevent overloading the generators at increasing head, but the device is also useful when running in parallel with other plants and convenient during load and efficiency tests, as the turbine can be given a constant gate opening during the whole test.

For the governor pump delivering pressure oil, herringbone-gear drive from the mainshaft has been used. An automatic cutoff valve permits the pump to deliver pressure oil only as long as the pressure in the accumulator is below the limit set, about 213 lb. per sq.in. *C* and *D*, Fig. 8, show governing results obtained at the acceptance tests. At these trials load was applied and taken off by means of the oil switch.

A future article will describe the method employed in testing these turbines after installation and give the results of the tests.

# Trend of the Times in Engineering

By HUBERT E. COLLINS

*The up-to-date power house is greatly different from that of ten or fifteen years ago. The boiler room, for instance, has become more important, relatively, as it now frequently represents the greatest opportunity of keeping down costs by efficient operation. Engines, turbines and other elements have passed through interesting cycles of development. Their relative values to the engineer can be better appreciated and their futures better understood by observations of these changes.*

THESE thoughts are written down for the readers of *Power*, for the reason that the writer's early training and experience make him feel at home with those who read it and kindred periodicals. How many of us stop to think of the fact that the passing years are bringing changes in our chosen field of work? I think we all do in a subconscious way. The struggle of life has always been so great for most of us, that it is hard to indulge in retrospection enough to realize all the changes in our time and the trend of the same.

Labor-saving devices reduce the number of individuals in one branch, as witness the fact that the modern boiler room needs less men per unit of output produced than it did only ten years ago. The same applies to the engine room. But along with this development of minimum labor per horsepower produced, has come a multiplicity of branches of the business for the individuals to go into.

### The Young Fireman Has Become a "Boiler-Room Engineer"

Who would have thought, in the old days, that the bright young fireman that he had, would develop into "a boiler room engineer"? This same young man now has grown in years and has charge of all the men in the boiler room in a large plant. In the old days he bothered the chief with a lot of questions. As soon as one question was answered, he had another. If the chief did not or could not answer the question, the young man found the answer elsewhere.

At present this young man is in the position where the firemen, coal passers, water tenders and repair men are all under his direction. He has an assistant to collect the daily record of coal and water used, as well as the amount of ash removal. This same assistant collects recording charts of the steam, vacuum and draft pressures from all over the boiler room.

The feed-water and flue-gas temperatures are taken from recording charts, also $CO_2$ and other gas analysis. The coal samples are analyzed each day. Hours run of boilers and auxiliaries are notated, together with the report of repairs.

After thinking over the metamorphosis of the former fireman, the old timer must contemplate the same for the former engineer. In the old small plant the engineer was engine, generator and switchboard attendant, as well as general repairman of the equipment. In the central station he had assistant engineers, oilers, wipers, dynamo attendants, and switchboard operators to assist. But he was the *big man* there and generally had charge of the boiler room as well.

Today the boiler room has taken the lead in importance, and the old-time all-around engineer has either gone higher or become less important in the functions of his position as engineer. If he has gone higher, he has a larger field than he ever had to choose from. Superintendent of works or the power plant may be his field.

The positions of master mechanic of maintenance department or of a works have claimed many. The position of electrical engineer in operation or design receives the attention of many former engineers. Others have succeeded as consultants for the many, applying the knowledge acquired in the engine room.

Readers of *Power* were treated last year to a series of reminiscences of W. H. Odell. The record as set down by him is intensely interesting and instructive. That this is so, is evidenced by the volume of comment following the series. Much more information of the same kind was sent in and adds to the store of this knowledge. All this is of immense value to the operating engineering field of literature. It should be followed up by more of the same kind. Such information is a record for future generations.

Boilers for stationary and marine service to carry pressures mostly not over 50 lb. up to the time of the Civil War in this country, began to give way to pressures over 100 lb. only thirty-five years ago. Since then the pressures allowed were, on the average, from 100 to 250 in the larger plants.

### Increase in Rotative Speed

Now, George Orrok is going to see one thousand pounds in use, as he preached so many years. Steam prime movers were all slow-speed in the reciprocating engine field until Charles T. Porter demonstrated at the Paris Exposition that 200 r.p.m. was both safe and feasible. Before that, fifty revolutions was considered the safe limit by most engineers. With the higher rotative speeds came shorter strokes, to keep the piston travel within the same bounds as before. With high rotative speeds came the governors in which the centrifugal forces were opposed by spring force, and a great field was opened up to compete with the Corliss type.

After 1890 the compounding of engines for stationary service to operate condensing, was a regular feature of design. The designers went to extremes for a while. They seemed to work on the theory that if a compound was better than a single cylinder, three cylinders would be better. We even had some six-cylinder engines. But finally we settled down to a proper ratio of two cylinders as the way to get the most from the steam.

In 1890 the average engine and boiler room was equipped with steam pressure and vacuum gages of the indicating variety. All the equipment now contained in these places, recording pressures, temperatures, and flue-gas analysis, has come into general use since then. Now we pay more attention to the boiler-room performances. Then the only requirement of the fireman was to give steam pressure to the engine room.

I think there is nothing so convincing as a study of the statistics on the power equipment of the United States, as compiled by the Census Bureau, Department of Manufactures.

HORSEPOWER OF PRIME MOVERS IN UNITED STATES OF AMERICA

| Privately Owned | 1899 | 1904 | 1909 | 1914 | 1919 |
|---|---|---|---|---|---|
| Reciprocating steam engines | 8,189,564 | 10,917,502 | 14,228,638 | 15,681,688 | 13,839,775 |
| Steam turbines | ..... | ..... | ..... | ..... | 3,198,198 |
| Internal-combustion engines | 134,742 | 289,423 | 751,186 | 991,905 | 1,259,400 |
| Waterwheels and motors | 1,454,112 | 1,647,880 | 1,822,888 | 1,826,843 | 1,767,588 |
| Total private power | 9,778,418 | 12,854,805 | 16,802,712 | 18,508,436 | 20,064,961 |
| Rented public service | 319,475 | 632,902 | 1,872,670 | 4,047,538 | 9,442,156 |
| Total public and private | 10,097,893 | 13,487,707 | 17,675,382 | 22,555,974 | 29,507,117 |

From this table we can see that the total power requirements in the United States increased threefold in the twenty years between 1899 and 1919. In other words, our field for employment has increased the same amount. This is one point which shows the trend of events in the engineering field and partly answers the question as to employment of the old and new adherents to the ranks of operating engineers.

### The Development of the Steam Turbine

About the first change in the trend of events in our field, to cause apprehension to some, was the coming of the steam turbine. Some of us felt that it would be a struggle or even an effort with failure at this end, to master the detail of the turbine enough so that we would be accepted as operators of the same.

To those of the latter way of thinking it was soon apparent that one could make a change over from reciprocating units to turbines without any real trouble. For those who still hold the view as stated, there is some solace in the 1919 census, of the privately owned plants. There we can see that the horsepower of the turbine units is only 18.8 per cent of the total horsepower for all steam-driven units. The percentage is no doubt about the same today in the privately owned field.

I have had years of experience checking up the turbines in industrial plants, and with all the faith of an enthusiast in new designs for greater economy, I have never met with the claimed efficiencies in every-day, year-in-and-year-out operation. They have been far better than the old reciprocating engines when the turbines are operating at proper speed and condensing, but hardly ever have they come up to claims.

Drawing on my experience of the past several years in many leading manufacturing plants in the Eastern section leads me to assert that on the average the yearly steam requirements of the plant are distributed, with one-third going to the generation of the electrical energy for power and light, one-third for heating during the cold days and one-third for process work and miscellaneous uses.

In an example of this kind the unaflow type is a money maker if it replaces even a turbine or the older types of reciprocating engines. While generating the electrical energy for the works, its exhaust can furnish steam for heat and process work free. I know well that we must discount the fact that the generation of the electrical energy will not be required during the night hours in the average factory and that steam heat must go on all night with live steam. This point is passed over by the average public-service salesman and many salesmen of prime movers for us. But allowing for this very evident fact, I still assert that the unaflow type can save money in the average plant.

# Steam Boilers

**A Catechism by Warren Hilleary Served in Small Doses and Extending Over a Number of Issues**

*57. A 72-in. boiler is bagged. The inner surface of the depression at its center is four inches lower than the original position. The diameter of the bag is 24 inches. The bag is in the center of the sheet and does not affect the seams. If the boiler cannot be patched, but can be repaired by having the bag driven back to position, would you consider the driving of it back to be a satisfactory repair? Assume that the material has not been sufficiently burned to materially lessen its strength.*

Such a repair, when properly made, would be acceptable, but only after reducing the original safe pressure allowance about 50 per cent, for although the molecular and chemical structure of the metal might appear to be unaffected, it never could be made to resume its original nature in all respects. Its original strength, therefore, probably would be impaired. Such a bag should be cut out and the sheet properly patched.

*58. Why are the staybolts in water legs of Heine boilers always made hollow?*

To serve as a safety alarm. When the staybolts are hollow, the presence of steam issuing through the hollow immediately indicates a fractured bolt. The reason for the diameter being so large is that the hollow may accommodate a steam nozzle for the purpose of blowing soot off the tubes.

*59. A 66-in. diameter return-tubular boiler is equipped with a steam dome. The dome is 30x30 in. and is riveted to the shell by a double row of rivets. A 6-in. hole is cut through the top of the shell in the center of the part covered by the dome flange. A crack in the boiler sheet extends longitudinally from the edge of the hole to a point one inch from the nearest dome flange rivet. The crack is open approximately ½ in. at the wide end. What repair, if any, would you recommend, always assuming that the boiler is being operated at the manufacturer's full rating?*

The whole sheet should be removed immediately, and a new sheet installed.

*60. A 54-in. horizontal tubular boiler with a double-riveted lap seam has one rivet head missing on the inside of the inner row of rivets. The boiler is otherwise in satisfactory condition. The owner states that it is impossible for him to have a new rivet inserted immediately and that it will be necessary to run the boiler a few months longer before repairs can be undertaken. Do you consider it safe to do so?*

This is a border-line question and may be properly answered either in the affirmative or negative, but it may be said that it is preferable to have a new rivet driven in immediately.

*61. A given size of horizontal tubular boiler is found to have three braces on one side of the top manhole and four braces on the other side. What should be done with the odd brace? Should it be left in or cut out, and why?*

If by calculation it is found that three braces on a side are ample, then no action need be taken. If, on the other hand, it is found that four braces are properly required on each side, then either the pressure must be reduced or an additional brace inserted.

# Furnaces for Burning Small Anthracites*

By A. R. Mumford
Fuel Engineer, New York Steam Corporation

**A SYSTEMATIC investigation of the composition of the gases in a boiler furnace at one of the plants of the New York Steam Corporation. Design of a furnace that raised the overall efficiency of the boiler when burning small anthracite on chain grates.**

THE progress of combustion was studied in the furnace of a water-tube boiler that was fired by two Coxe chain-grate stokers. The investigation may be divided into five parts showing: (1) Combustion conditions during normal operation; (2) the effect on combustion of raising the front arch; (3) the effect of air introduced into the furnace through jets under pressure; (4) the effect of steam jets at the rear of the furnace introduced to stimulate a rear arch; (5) the effect on combustion of a rear arch installed in a furnace with a low front arch.

The boiler was a four-drum Edge Moor water-tube boiler, 29 and 30 tubes wide and 16 tubes high, containing 10,000 sq.ft. of heating surface. The gases crossed the tubes three times in their path through the boiler, which was baffled by the ordinary Edge Moor type baffles.

Beneath the stoker grate were four separate air chambers to which air was supplied through three windboxes from a main air duct, and in the studies the grates were considered to be divided into four sections, one over each air chamber. Each windbox was equipped with slide dampers to control the air pressure under the section of the grate above the corresponding air chamber. The fourth airbox was divided by two vertical partitions into three compartments, each controlled by a damper, so that if a hole appeared in the fuel bed, the damper to the lateral compartment under the hole

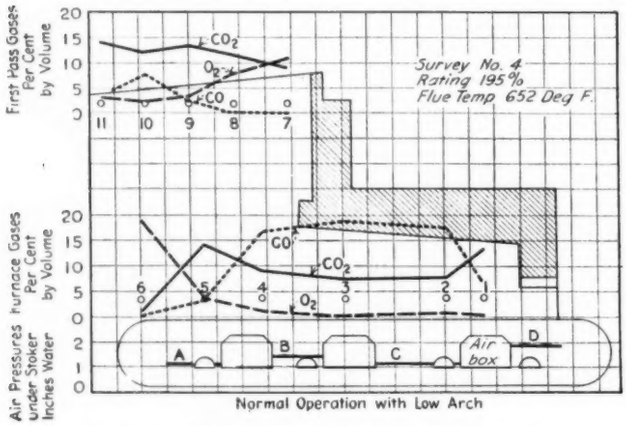

First Pass Gases Per Cent by Volume
Survey No. 4
Rating 195%
Flue Temp. 652 Deg. F.
Furnace Gases Per Cent by Volume
Air Pressures under Stoker Inches Water
Air box
Normal Operation with Low Arch

*Fig. 1—Normal operation with low arch*

could be closed to prevent too great an amount of air from entering the furnace.

Observation of the ordinary operation of the boiler, furnace and stokers in the plant on which the studies were made, indicated that losses existed because of the large amount of combustible in the refuse, because of high flue-gas temperature and because of the presence of CO in the flue gases. The loss due to combustible in the refuse was high, partly because it was necessary to carry long fires to attain the required steam output, and partly because particles of solid combustible were blown from the front of the grate and carried in suspension by the gases until the end of the stoker was reached, where the particles settled out of the gases and fell to the ashpit. The high flue-gas temperature was due to the combustion of CO in the boiler. The loss due to carbon monoxide in the flue gases and that due to high flue temperatures were evidently caused by poor mixing action in the furnace.

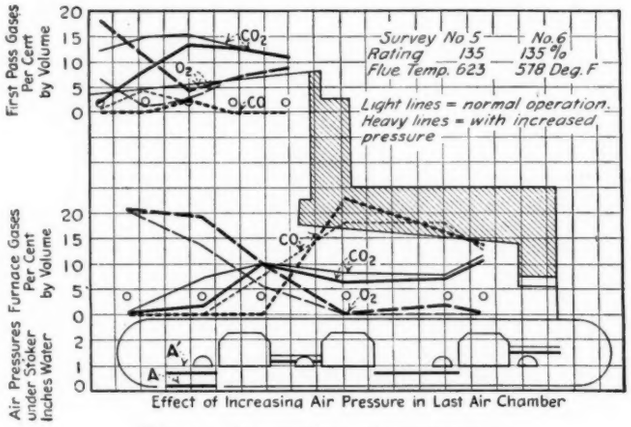

First Pass Gases Per Cent by Volume
Survey No 5 No 6
Rating 135 135%
Flue Temp. 623 518 Deg. F
Light lines = normal operation.
Heavy lines = with increased pressure
Furnace Gases Per Cent by Volume
Air Pressures under Stoker Inches Water
Effect of Increasing Air Pressure in Last Air Chamber

*Fig. 2—Increasing air pressure*

In order to learn how the mixing action of the furnace might be improved and to outline accurately the path of the gases through the furnace, simultaneous samples of the gases in the furnace were collected at eleven points, by means of a special sampling tube which drew gas from the whole width of the uptake. Six of these points were on a horizontal line about six inches above the fuel bed and five on a horizontal line just below the boiler tubes. The temperature of the flue gases was measured by copper-constantan thermocouples inserted in the openings between the drums just below the uptake. In order to eliminate any error from momentary changes in the fuel bed, the gas samples were collected over a period of twenty minutes.

The results of some of the studies of the furnace gases are plotted on the charts, Figs. 1 to 7 inclusive. The holes through which the sampling tubes were inserted into the furnace are indicated by small circles and numbers in Fig. 1. The composition of the gases at the several points is shown by the lines marked $CO_2$, $O_2$ and CO. The percentage of $CO_2$ is represented by a solid line, $O_2$ by a line composed of long dashes, and the percentage of CO by short dashes. The pressure of air in each of the four air chambers is represented by a horizontal line *A*, *B*, etc., drawn across each section.

In Fig. 1 is shown the composition of the furnace gases under normal operating conditions. A study of

*Extract of paper read before the Metropolitan Section of the American Society of Mechanical Engineers.

the curves shows that immediately over the fuel bed at the front half of the furnace, there is little or no oxygen present and considerable combustible gas. At the rear half of the furnace considerable oxygen is present and little or no combustible gas. In the first pass more oxygen is present near the curtain wall than near the bridge wall, and conversely, no combustible gas is present near the curtain wall, although a rather large amount is present near the bridge wall.

As the coal falls onto the moving grate, it is brought forward slowly and exposed to radiation from the furnace brickwork. After the coal is dried, ignition takes place first of all at the upper surface of the fuel bed, and the air passing through the layer of coal unites with the ignited coal and combustion begins. The rise in temperature caused by this combustion at the surface of the fuel bed is communicated to the lower layers of the coal by conduction, and these lower layers then ignite and burn.

As the fuel bed becomes fully ignited, the oxygen in the air passing through the fuel is completely used up in the lower layers, where it gasifies carbon, forming $CO_2$, some of which is reduced by contact with carbon to CO. Fully one-third of the length of the grate is covered by the fuel undergoing this change, and consequently a large volume of combustible gas is formed. This action continues until the carbon or combustible content of the fuel bed is lowered sufficiently to allow $CO_2$ to pass through with little reduction to CO. The amount of combustible on the grate diminishes rapidly from this point on, and more and more free oxygen passes through the fuel bed until no $CO_2$ or CO is formed.

The extent of the mixing action of the furnace on the stream of gas can be seen by the changes in composition of the gases which have taken place between the grate level and the point of entrance to the boiler. At points 7 and 8 no CO was ordinarily present under

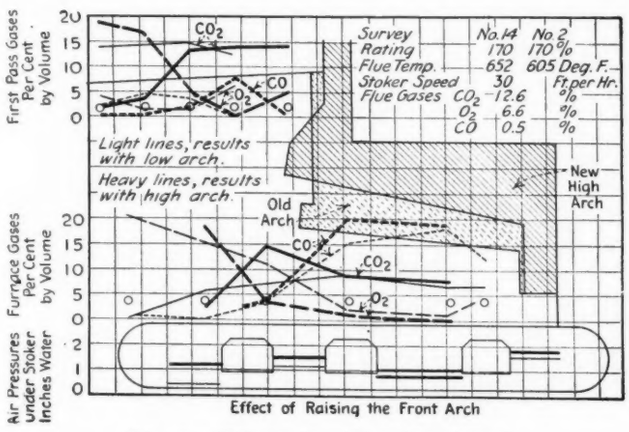



*Fig. 3—Effect of raising front arch*

normal operating conditions. The burning out of CO was probably due to the fact that the air from the front of the stoker passed along just under the main arch, mixing with the combustible gas and burning it. The presence of CO at points 9, 10 and 11 indicated that insufficient air was introduced into the main stream of combustible gas.

It was found that combustion at point 1 was more complete when the grate traveled faster, and this indicated that more air entered the furnace at the front. An increase in air entering at the front of the furnace could take place only through green coal, and if the thickness of the fuel bed and the pressure of air in the first air chamber were the same, then to account for the more complete combustion at point 1 there must have been a larger area of green coal exposed to the pressure in the first air chamber at higher grate speeds. In other words, as the grate traveled faster, ignition took place later. It was also found that the air from the front was responsible for the burning out of CO by the time the gases reached points 7 and 8, for, with the reduced air pressure in the first air chamber, CO was found at points 7 and 8. To circumvent the later ignition at higher grate speeds, radiation to the

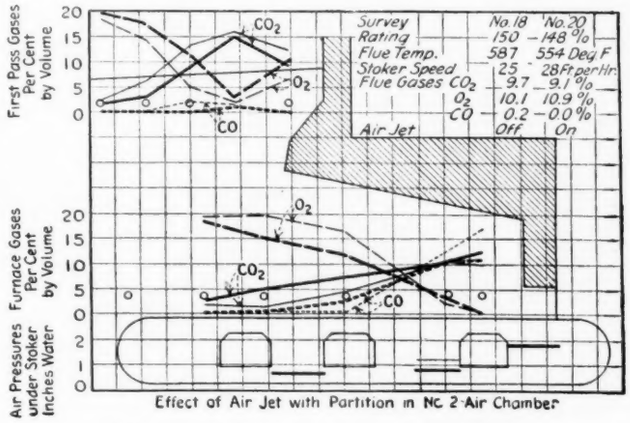



*Fig. 4—Using air jet in air chamber*

green coal must be increased by an increase in the area of radiating surface or by removing the obstruction caused by a thick ignition arch.

A study of the normal operating conditions indicated three possibilities for improvement. If the velocity of the gases as they pass under the front arch could be reduced materially, the number of particles of solid combustible carried to the rear of the stoker would be reduced. The obvious method of decreasing the gas velocity was to increase the cross-sectional area of the furnace under the front arch by building a higher arch.

In order to burn out the combustible on the grates completely, more air must be forced through the fuel bed on the last stoker section so as to complete the combustion in the furnace. It might be advisable to introduce air into the furnace through jets under pressure in order to complete combustion in the furnace.

In order to study the effect of adding more air by increasing the pressure in the last air chamber, a set of samples was collected with no change other than the increase in pressure mentioned. The results are given in Fig. 2, *A* being the usual pressure for the given load condition and *A'* the pressure actually carried.

The results show that immediately above the fuel bed the gas composition did not change appreciably at the front of the furnace, but at the rear the oxygen was much higher with the higher pressure. At the entrance to the first pass the effect of the increased air supply was very evident. At point 9 there was evidence of the additional air, while at points 10 and 11 the rapid fall of the $CO_2$ and the rise of the $O_2$ indicated that the additional air materially affected the gases passing these points. Thus it is seen that an increase in the amount of air entering the furnace through the refuse

does not necessarily imply that this air will mix with the combustible gases, because this additional air apparently clings close to the bridge wall and rises directly to the boiler. Any additional air admitted through the refuse must be directed toward the front of the furnace by some form of arch or other means to compel it to mix with the combustible gases.

In an attempt to reduce the loss from particles of solid combustible blown from the front of the grate and carried to the ashpit, the main arch was raised one foot at the front and two feet at the rear, thus increasing the cross-sectional area at the rear by about sixteen square feet and by about eight square feet at

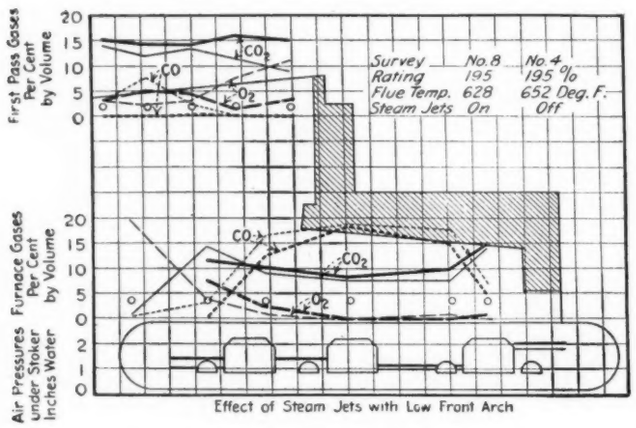

First Pass Gases Per Cent by Volume
Furnace Gases Per Cent by Volume
Air Pressures under Stoker Inches Water
CO2
CO
O2
Survey No.8 No.4
Rating 195 195 %
Flue Temp. 628 652 Deg. F.
Steam Jets On Off
Effect of Steam Jets with Low Front Arch

*Fig. 5—Air jet used with low arch*

the front, Fig. 3 reducing the mean horizontal velocity by the same proportion.

The change indicated that the quantity of particles of solid combustible dropping from the gases to the ashpit was decreased, although the decrease was not so great as might be expected. The actual stream of gas could be observed to rise immediately at the end of the front arch, not continuing to the bridge wall as was the case with the low arch. It was concluded that the reduction in horizontal gas velocity under the front arch was sufficient to reduce the loss from particles of solid combustible somewhat, but that its greatest effect was to change the point at which the main gas stream entered the boiler from next the bridge wall to near the curtain wall. The composition of the gases over the fuel bed and entering the boiler are shown by the heavy line in Fig. 3.

If raising the front arch is to improve combustion, the percentage of $CO_2$ in the gases entering the boiler must be higher and the percentage of CO must be lower than with a low arch. It was impossible to determine exactly what weight to give the analyses at the various points, but if we assume that the points apparently in the main gas stream should be weighted according to the rough measurements of velocity that were made, points 9, 10 and 11 would have a weight of 4 to a weight of 1 for points 7 and 8, with the low arch in service. With the high arch points 7, 8 and 9 would have a weight of 4 and points 10 and 11 a weight of 1. Using the foregoing approximation, the average composition of the gases entering the boiler shown in Fig. 3 was as follows:

| Gas composition entering the boiler | $CO_2$ | $O_2$ | CO | $N_2$ |
|---|---|---|---|---|
| With low arch | 13.8 | 2.9 | 2.9 | 80.4 |
| With high arch | 12.1 | 5.4 | 2.8 | 79.7 |

From the foregoing it is evident that there was little change in the amount of combustible gas entering the boiler, but there was a reduction in the amount of $CO_2$ and an increase of oxygen, so that the gas composition was not favorable to the high arch. The changes in the composition of the gases over the fuel bed were evidently not due to the change in arches.

The heavy lines in Fig. 3 show the effect of an air jet on combustion. The air jet at about 25 lb. pressure was introduced through the side wall of the furnace about a foot below the end of the front arch. The difference in the composition of the gases over the fuel bed were caused by slight differences in the lengths of the fire.

As shown in Fig. 4, the oxygen at points 7 to 11 inclusive was higher with the air jet in service, and the $CO_2$ and CO were lower. Thus the air jet reduced the amount of CO in the gases entering the boiler, but it accomplished this with a substantial increase in excess air. At high ratings a reduction in the amount of CO in the gases entering the boiler took place, accompanied, as at low ratings, with a decrease of $CO_2$ and an increase in oxygen when the air jet was in service.

The effect of an air jet in burning out CO seems to be balanced by an increase in flue-gas loss due to excess air, so that little real benefit is derived from its use. In addition it is illogical to provide an air supply above the fire if air can be forced through the refuse and properly mixed with the combustible gases. That the logical place for the admission of any air necessary for combustion is through the refuse is evident from the fact that air entering the furnace in such a manner must gasify some carbon and so reduce the loss due to combustible in the refuse.

In order to stimulate the action of a rear arch without waiting for its construction, a system of steam jets was introduced across the stoker at point No. 6 at the rear of the furnace. The effect of the steam jets with

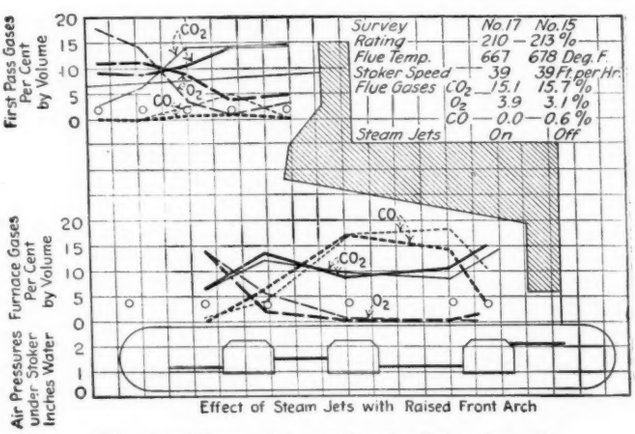

First Pass Gases Per Cent by Volume
Furnace Gases Per Cent by Volume
Air Pressures under Stoker Inches Water
CO2
CO
O2
Survey No.17 No.15
Rating 210 — 213 %
Flue Temp. 667 678 Deg. F.
Stoker Speed 39 39 Ft. per Hr.
Flue Gases CO2 15.1 15.7 %
O2 3.9 3.1 %
CO 0.0 — 0.6 %
Steam Jets On Off
Effect of Steam Jets with Raised Front Arch

*Fig. 6—Steam jets and raised front arch*

the low arch in service is shown in Fig. 5. In this chart the lighter lines indicate the gas composition under normal operation and the heavy lines the composition with the steam jets in service. The combustion of the coal on the grates was, of course, unaffected by the steam jets. In the first pass, however, the effect of the additional air and the mixing action of the jets was evident. The air rising through the refuse was forced forward by the action of the steam jets and

mixed with the main gas stream. The oxygen in this air was thus brought into contact with the combustible gas and combined with it, burning the CO and increasing the $CO_2$. The composition of the gases in the first pass shows that by the time the gases had reached the boiler tubes the CO was entirely eliminated.

Because some of the arches in the boilers at the palnt had been raised, it was desirable to learn the relative effect of steam jets on the combustion in a high-arch boiler. The curves in Fig. 6 show the results of an investigation on a high-arch boiler with and without steam jets. The heavy lines indicate the composition with the steam jets in service and the light lines the composition under normal operation conditions. The

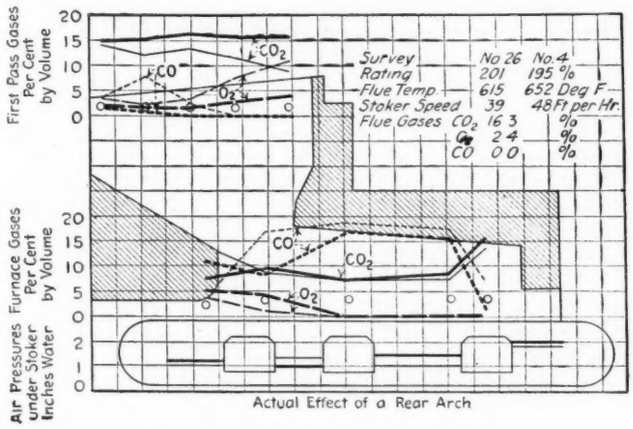



*Fig. 7—Furnace with rear arch*

earlier turning of the main gas stream and the shorter distance between the arch and the boiler tubes made it more difficult to mix the gases from the rear of the stoker with the combustible gas; this is shown by the lesser degree of success attained by the use of steam jets.

It is evident that steam jets (used to simulate a rear arch) were effective with a high arch, but not so effective as they were with a low arch. This fact is of importance in deciding the best arch arrangement over a chain-grate stoker burning small sizes of anthracite.

In order to confirm the conclusions drawn from the action of steam jets, a Detrick flat-suspended arch was installed in the rear of a low-arch furnace. The rear arch was suspended 10 in. above the grate and extended 5 ft. forward from the bridge wall. The boiler was operated for several days at ratings varying between 250 and 270 per cent in order to learn the ability of the arch to withstand the best of the furnace before a study of the furnace gases were undertaken. It was noticed during this preliminary operation that the dropping of particles of solid combustible matter from the gases to the ashpit was stopped completely and that this material dropped to the roof of the suspended arch instead. On the roof of the suspended arch the combustible material seemed to burn out, leaving a layer of ash that increased in thickness until it flowed slowly toward the grates, forming "whiskers" on the nose of the arch. The nose of the arch itself was brilliantly incandescent, although a layer of clear gas from the last stoker section seemed to cling to the surface of it. In rising to the boiler, there seemed to be an expansion of the gas stream so that the whole width of the first pass was taken up by the gases entering the boiler. The shape of the arch and its relation to the furnace are shown in Fig. 7.

The results of a study of the furnace gases with the rear arch (heavy lines) are superimposed in Fig. 7, on the results of a study of the furnace gases without the rear arch installed (light lines). Over the fuel bed the gas composition is different, although this is obviously not due wholly to the rear arch. The air pressure in air chamber *A* was maintained considerably higher with the rear arch in service, and the refuse passing over the end of the stoker appeared well burnt out.

In the first pass the gas composition shows that the $CO_2$ is higher at all points and that the CO is lower. The arithmetical averages of the gas composition show that without the rear arch about one-fifth of the CO formed in the furnace entered the boiler and that with the rear arch in service only one-twentieth of the CO formed in the furnace entered the boiler. These facts indicate that the rear arch as installed greatly improved the mixing action of the furnace. The analysis of the flue gases shows a favorable condition. The flue temperature shows a reduction of about 35 deg. F., which in itself indicates a considerable saving.

The investigations reported in this paper were carried out on a Dutch-oven type of furnace, and the indications are that some such type is necessary to produce mixing. Air and combustible gases are present at the front of the stoker, and some arch over this section is necessary to force the two streams into contact. Because the air entering the furnace at the front is generally insufficient to supply all the necessary oxygen, the combustible gases from the front must be forced to pass over the refuse section of the grate in order to come in contact with the free oxygen in the gases rising from this section. This action can be accomplished by placing the stoker completely under an arch and thus prevent any of the gas from entering the boiler until it has passed over the refuse section. This form of furnace would have obvious disadvantages from the viewpoint of upkeep because intense gaseous combustion would probably take place over the refuse section and the arch would be subjected to the resulting high temperature at this point. It is well, therefore, to shorten the main arch from this extreme length to a length that will permit radiation to the boiler to cool the brickwork at the point where the most intense combustion will take place. If the front arch is shortened in this manner, it is necessary to install a rear arch to prevent the gases from the refuse section from rising directly to the boiler and to force them to travel toward the front of the furnace far enough to insure their mixing with the main stream containing combustible gas.

The details of the dimensions of such a furnace would vary with the height of the setting available, because the higher the setting the more time there will be available for the completion of combustion. Conversely, the lower a setting is, the more effective must be the action of the mixing devices in order that combustion be completed before the gases reach the boiler. However, it seems necessary to utilize arches in the manner suggested to carry gas streams from the front and from the rear of the stoker if combustion is to be completed in the furnace.

# Chasing Bubbles in a Boiler

## An Outline of Where Steam Forms in a Boiler and the Path of the Water Circulation—Description of a Glass Model Boiler Used in the Study

THERE are several hundred thousand engineers in charge of boiler plants who pride themselves in knowing all about boilers. If asked the question, "What is the water circulation in a boiler?" each and every one would have a very definite opinion, although the answers of any ten would not agree. Ask yourself this question and see how near your answer approaches the real facts as here outlined.

The wide divergence in opinion as well as the lack of actual information possessed by even those conceded to be the "knowing ones" in boiler design, was strikingly brought out in a contest instituted by the E. Keeler Company. Under the terms of the contest the engineer who described correctly the circulation in the horizontal return-tubular boiler was to be awarded a prize. Hundreds of engineers and engineering associations entered the contest, and the variety in answers almost equaled the number of contestants. A local of the National Association of Stationary Engineers won the prize, the answer, which was a composite of its members' opinions, being practically correct. Incidentally, some of the members actually constructed a glass model of the boiler before submitting their answer, and so were playing a "sure shot."

The widely differing opinions are not to be wondered at for the reason that whenever this subject has been touched upon by technical journals, a correct circulation has never been shown, and it may be mentioned that in recent textbooks the circulation in return-tubular boilers is described in accordance with the previously accepted idea on the subject; that is, that the circulation path is upward at the front head, backward on the surface to the rear head, then downward at the rear, with a distinct forward circulation along the shell at the bottom, as shown in Fig. 1. After several years' experimental work, A. C. Lippincott, of the E. Keeler Co., succeeded in constructing a working glass model for demonstrating purposes before steam engineering organizations. The dimensions are to all intents in proportion to those of an actual boiler, and it is therefore possible to determine the circulation in a boiler of standard capacity.

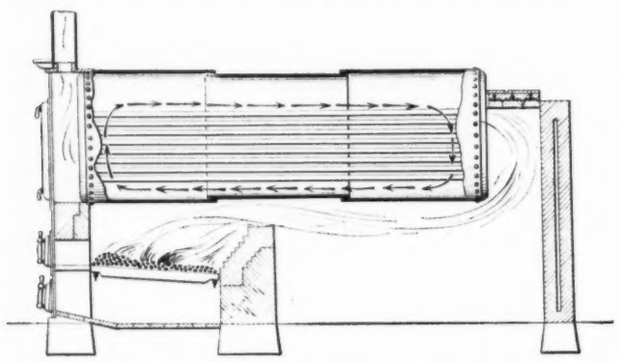


*Fig. 1—Popular idea of how water circulates in a boiler*

Examination of the glass model shows that the water and steam mixture rises up along the front head, as indicated in Fig. 2, at a high velocity, and after releasing the steam bubbles, the water moves toward the rear until it reaches a point a little beyond the center of the boiler, whereupon it drops downward. Upon reaching the lower part of the boiler, the main part of the stream turns toward the boiler front, while a part flows toward the rear. There is a secondary steaming zone at the rear head, causing an upward flow, the current then flowing toward the front and downward, making a loop. These two actions cause the circulation of the water to be in the form of a figure 8 placed horizontally, thus, ∞. The two streams interconnect as indicated in Fig. 2, but the major part of the steam bubbles are formed in the immediate vicinity of the front head. Tea leaves placed in the boiler show that at the middle of the boiler, where the two streams cross, the circulation between any pair of tubes may be upward at one time, followed by a downward motion. The leaves also reveal that, contrary to the popular belief, there is no area of quietude in the boiler; leaves placed just above the blowoff are finally thrown into circulation. Likewise the argument that sediment will deposit on the belly of the boiler just above the bridge wall apparently has no basis, for the velocity of the water at this point is very high.

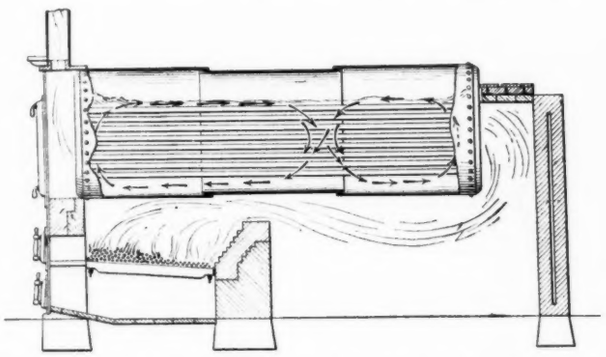


*Fig. 2—Actual circulation as determined by study of a model boiler*

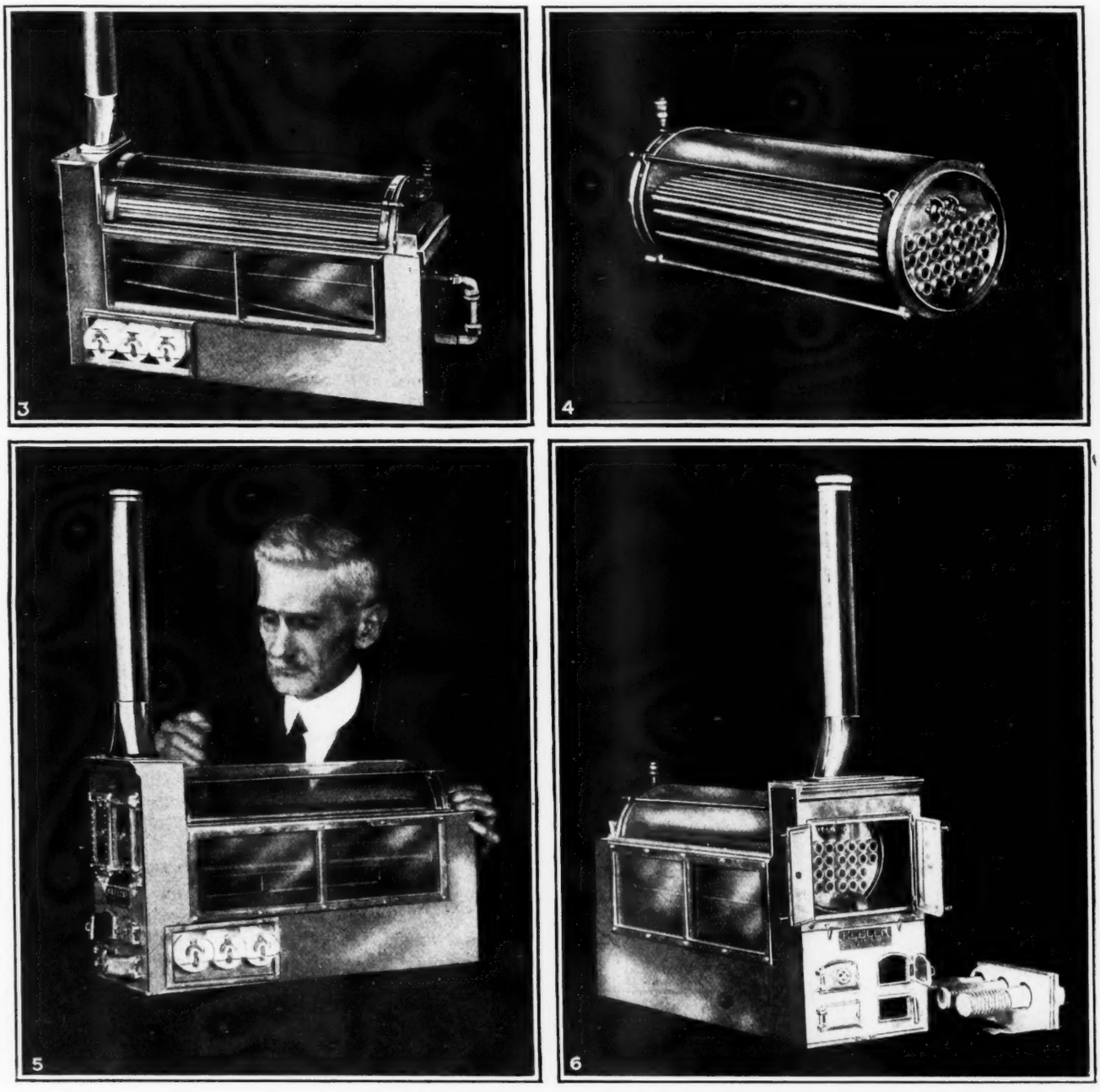
Strangest of the deductions to be made is that the water has the greatest ebullition along the front head. The front tube sheet is the coldest part of the boiler, much lower in temperature than is the rear tube sheet. It seems that the water immediately above the furnace absorbs heat rapidly and begins boiling. The upward circulation causes a flow of water from the rear, and the velocity set up is great enough to carry this water forward until it strikes the front sheet, whereupon the flow is upward between the tubes, the circulation shifting the natural upward path from being directly over the fire, to the front tube sheet. This is so violent that the water is driven up against the top shell, incidentally showing that the steam and safety outlets should not be located well forward.

The circulation at the rear head is what is to be expected, since this part of the boiler is at a fairly high temperature. It may be stated with considerable accu-

racy that the greater part of the heat of combustion is absorbed by the boiler shell and that the gas temperature at the rear tube sheet is far below the furnace temperature.

An interesting experiment was conducted on the model boiler to determine the value of an external circulation tube placed in the furnace. For many years an occasional boiler has been fitted out with one or more "drop tubes" connected to the rear and front heads of the boiler by suitable fittings and passing through the furnace. The belief was that this pipe increased the boiler efficiency as well as the circulation. The model was equipped with one drop tube, as shown in Fig. 3, with a short section of gage glass in the circuit, and while no efficiency tests were run, it is significant that the pipe did lessen the time required to raise steam by *50 per cent.* When steaming, the circulation was increased to a marked extent.

The Lippincott glass model boiler is shown in the illustrations on this page. The shell of the boiler, Fig. 4, is of pyrex glass, the heads of brass, while the tubes are of brass held into the front head by locknuts. External through bolts hold the heads, relieving the tube ends of much of the head pressure. The boiler setting or casing is of planished sheet aluminum, well insulated, and the front frame and doors are of cast aluminum, as is also the chimney. Three electric resistance coils supply the necessary heat, these being preferred to a gas flame. The type of heat apparatus does not alter the path of circulation to any extest, even when the flames of two gasoline torches are thrown into the furnace and against the rear "wall."




*Figs. 3 to 6—Views of model boiler*

# Generator Automatic Voltage Regulators —Care and Adjustment

## Conditions That Must Prevail for Proper Voltage Regulation—Adjustment of Field Rheostats and Regulator for Rate of Building Voltage Up or Down—Putting Regulator Into Service—Prevention of Operating Troubles

By J. H. Ashbaugh
Engineer, Supply Engineering Department, Westinghouse Electric & Manufacturing Company

GENERATOR voltage regulators of the vibrating type are generally considered complicated. The result of this is a lack of knowledge of this piece of apparatus, and in case of trouble the cause is frequently attributed to the regulator, whereas the real trouble may be either in the handling of the regulator or the adjustment of the machines. The correct functioning of the vibrating voltage regulator depends on the exciter and generator; thus if the exciter does not respond to the command of the regulator, or if the generator rheostat is improperly set, the system may function when the load is steady, but if the load suddenly changes the regulator may be upset, thereby disturbing the equilibrium and under extreme conditions surging or some kindred trouble may ensue. Too often the regulator is compelled to attempt to compensate for conditions introduced by the improper adjustment of the machines. Likewise adjustments are at times made on the regulator to offset the improper machine adjustments.

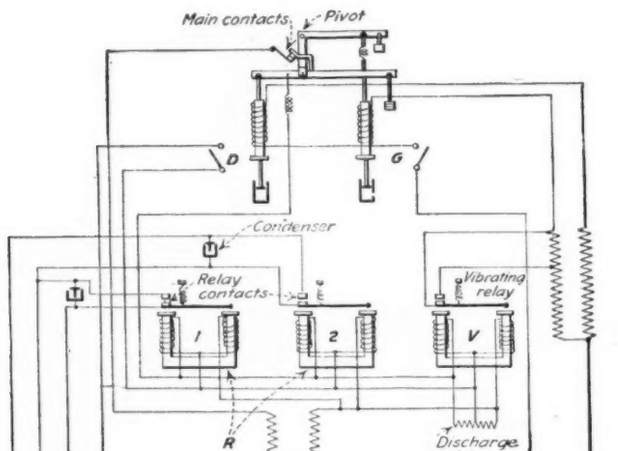



*Fig. 1—Diagram of regulator that can control the exciter's voltage from saturation to maximum*

The foregoing was demonstrated in one instance when the regulator was criticized for its poor operation. The trouble in this case was due to the short-circuiting of the series field winding of the exciter. Shunt machines are always to be preferred, and in this case the series-winding was merely short-circuited instead of open-circuited. This short-circuited winding acted as a damper around each pole, making the machine sluggish and requiring more rheostat resistance in the shunt field in order to get in to build down quickly enough, so that the contacts burnt very rapidly with this additional load. Opening this winding entirely overcame the trouble.

There are several different types of installations. These can be grouped into three general classes and they are determined by the conditions which control the station layout. These classes are: (1) Individual exciter and regulator for each alternator; (2) Individual exciter for each alternator and one regulator for the entire station; (3) common exciter and one regulator for the station, or exciters operated in parallel and one regulator. In the first and second cases it is quite common to omit the generator-field rheostats, but in the third case they are required for the proper division of wattless load.

In stations where a storage battery or some other constant-potential source is available and a regulator with both of the control coils operated from the alternating-current voltage, the rheostat shunting relays 1 and 2 in Fig. 1, can be excited from the battery, thereby permitting the exciter to operate over a voltage range from residual to the maximum. When this connection is employed, the generator field rheostat *H* plays no part in the voltage control and can either be omitted or turned to the all-out position.

When the rheostat-shunting relays are connected to the exciter or the type of regulator used which has one control coil operated from the exciter voltage, shown in Fig. 2, it is necessary to set the generator-field rheostat *H* so that at no load the exciter voltage will be the same as the lower-voltage range of the regulator. In other words the relays or any direct-current coil can operate only over a limited range, as too low a voltage will not permit sufficient power and too high a voltage will cause them to burn out. The lower limit of the range is the minimum voltage that will insure good operation, and each regulator is so marked on the name-plate under the title of direct-current volts. The rheostat should be plainly marked in this position, as it is the normal operating position. Each generator requires a certain voltage across the slip rings at normal speed and voltage. Owing to the inherent regulation it is necessary to increase this slip-ring voltage

with the load in order to keep the same alternating-current voltage, so that a higher voltage is required at full load. The change in excitation voltage from no load to full load is called the range of excitation. In some cases the exciter voltage will have to vary over a wider range than that over which the relays will operate. When this condition prevails, it will be necessary to change the position of the generator rheostat *H* with the load to keep the exciter voltage at all times within the range of the regulator. Thus the automatic

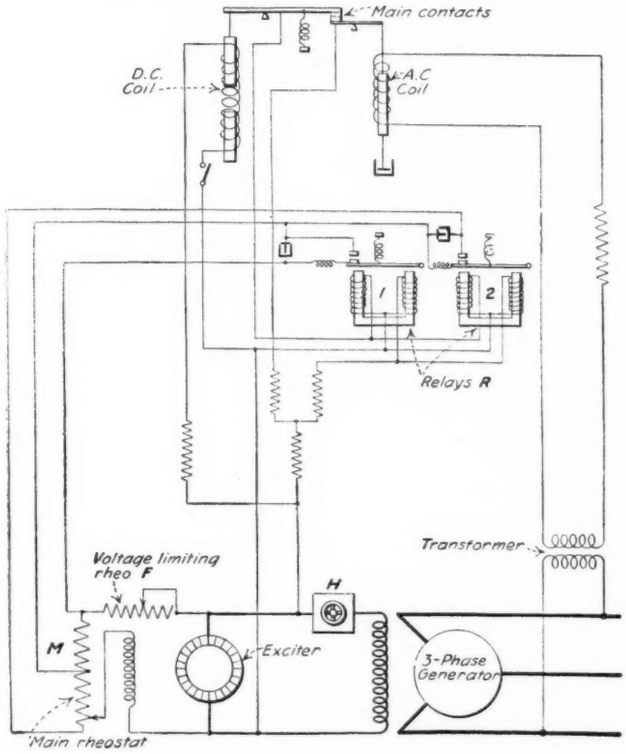



*Fig. 2—Diagram of regulator with a limited range of voltage regulation*

regulator will have to be supplemented by some hand operation. The only remedy for this condition is to provide some external source of power for the relays as suggested in Fig. 1. This is feasible only with a control element having both coils excited from the alternating-current voltage. With this arrangement complete automatic regulation is obtained. If there is no external source of power in the station, then the main alternator-field rheostat will have to be altered with the load in order to keep the exciter voltage within the limits of the regulator. This operation is not objectionable where the load is moderately steady.

Frequently, several machines are operated in parallel with exciters in parallel (Case 3). All the generator-field rheostats must be set so that the exciter-bus voltage is the lower limit of the voltage-regulator range. When the alternators require different values of excitation voltage and exciters are operated in parallel, all the generator-field rheostats should be adjusted to agree with the one requiring the highest no-load excitation.

The generator-field rheostats are only a means of keeping the exciter voltage from varying over too wide limits, thereby insuring sufficient voltage for the regulator at light loads and preventing injury at heavy loads. The alternator-field rheostat, when cut partly in, helps the time required for the regulator to bring the voltage back to normal under sudden load changes by reducing the time required to change the field current with a given applied voltage change. That is, it reduces the ratio of the inductance to the resistance and thereby the natural time constant of the field.

The adjustment of the exciter is of prime importance. This machine can be made to change its voltage fast or slow with a given rheostat change, so that the response of the whole unit hinges on this machine. It is quite common practice to supply two rheostats connected in series with each exciter—one the main regulating rheostat *M*, Figs. 1 and 2, and the other the voltage-limiting rheostat *F*. The voltage-limiting rheostat limits the exciter voltage, but not necessarily the alternator's voltage, as the value to which the exciter voltage is limited is far in excess of that required to limit the voltage of the alternating-current machine at no load. If the alternator was at no load, the saturation of this machine would be the limiting factor rather than the exciter, even though the exciter was limited to slightly above the full-load field requirements. It is not practicable to limit the exciter voltage to a value that would limit the alternating-current voltage. The voltage-limiting rheostat is sometimes erroneously used to limit the voltage of the exciter so that in case of regulator failure the exciter will go only slightly above the full-load value. This practice is very bad, as it usually results in poor operation of the regulator. In reality the only use of the voltage-limiting rheostat is to make it more convenient in operating the station and to get the proper time-constant adjustments.

### Adjusting Building-up and Building-down Time

The proper time for building up and building down the voltage can be adjusted by the voltage-limiting and the main regulator rheostat, and how this is done will be made the subject of another article. These rheostats should be adjusted until the building-up and building-down periods are about equal and should be measured with a stop watch. In taking these time measurements, the disconnecting switches *D* and *G*, Fig. 3, should be open. These cut the alternating-current power out of the vibrating and control coils *A* and *M* and the direct-current power out of the relay coils 1, 2, etc. This allows the contacts on the relays to close and short-circuit the control sections of the main field rheostat. Then by opening and closing the disconnect switches *E* in the contact circuits, the voltage can be caused to build up and down at will. Closing the switches allows the voltage to build up, and opening the switches has the same effect as opening the contacts and causes the voltage to build down.

The voltage-limiting rheostat should be set first. The time should be measured from 30 volts to 125 volts on a 125-volt exciter, or in case of a 250-volt exciter the time is 60 volts to 250 volts. The voltage-limiting rheostat should be varied till this time is approximately three seconds. The voltage will go in excess of the nominal rating (125 or 250), but that is desirable. Likewise the voltage will fall below the lower limit, going to about 15 or 20 volts on a 125-volt machine. After the time to build up has been determined, the rheostat should be marked in this position. The time to build down is determined by the position of the main-regulating rheostat *M*, and this should be set next. With the stop watch the time to build down from 125 to 30 volts should be adjusted by varying this

rheostat, after which it should be marked. When the regulator is in operation, this rheostat should not be varied, but should always be on the marked position.

After the building-up and building-down periods have been adjusted the regulator adjustments should be made. An unloaded machine running at normal speed and on an idle bus is required to make these adjustments. With all the rheostats in the proper position, as determined by the method given in the previous paragraph, switches *D* and *G*, Fig. 3, should be closed. The main regulating rheostat *M*, Fig. 1, is then turned to bring the alternating-current voltage to normal and

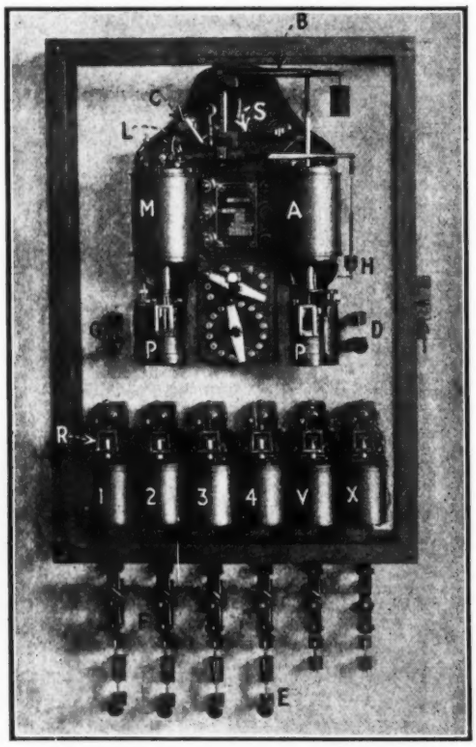



*Fig. 3—Alternator Automatic Voltage Regulator*

*A*, vibrating magnet; *B*, bell-crank lever; *C*, main contact; *D*, direct-current disconnect switch; *E*, relay-contact disconnect switches; *F*, reversing switches; *G*, alternating-current disconnect switch; *H*, counterweight; *L*, floating lever; *M*, main control magnet coil; *P*, dashpot; *R*, relay contacts; *S*, main control-magnet spring; *V*, vibrating relay; *X*, master relay; 1, 2, 3 and 4, rheostat-shunting relays.

the relay disconnect switches *E* closed. The main regulating rheostat should now be turned back to the previous position. The regulator will begin to vibrate and hold the alternating-current voltage normal.

The next adjustment is the main-control magnet springs. The exciter voltage should be raised by turning the alternator's field rheostat *H*, Fig. 1, in until this voltage is midway of the regulator's range. The exciter rheostat must not be altered. This voltage point is, for example, 105 volts on a regulator having a range of 60 to 150 volts. The spring *S* should be changed so as to bring the floating lever *L* to a horizontal position. If there are no generator-field rheostats, then the floating lever should assume a position that the left-hand end is ½ in. above the horizontal position.

The dashpots *P*, Fig. 3, should be adjusted to obtain the best settling time; that is, open the relay disconnecting switches *E* allowing the voltage to fall to a minimum, after which they should be closed and the time required to settle the voltage noted. This settling time can be varied by changing the needle valves on the dashpots and should be adjusted to give the smallest time. The vibrating magnet *A* should be lightly damped as it is the quick responding element. The main-control magnet *M* should be more heavily damped, depending on the machine, but various adjustments should be tried till the quickest time of settling is obtained.

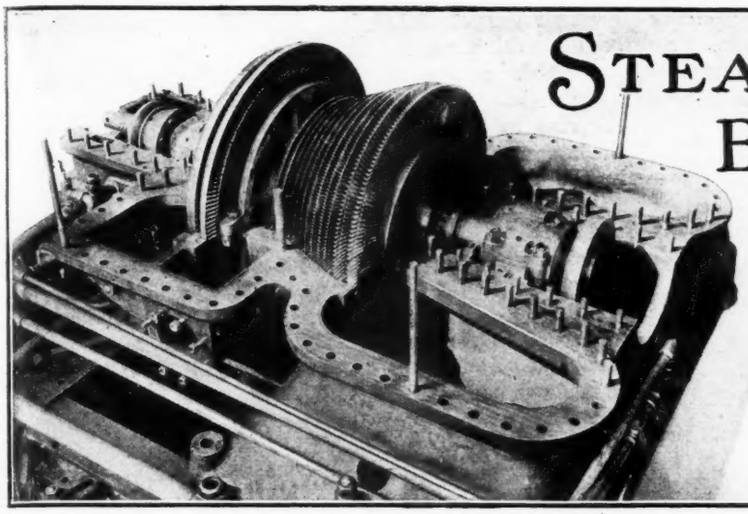
The trouble that is experienced after the regulator has been installed is in a majority of cases with the rheostat-shunting relays contacts. This is due in a large measure to the different conditions in each installation; namely, the field current, length of leads to the exciter, etc. Usually, the condensers are placed across these contacts to absorb the arc. It is highly desirable to have them arc somewhat as it wears them to a smooth surface, preventing projections from being formed. The action of the condenser when used for this purpose is interesting, and trouble can sometimes be prevented when this action is understood. After the contacts have opened, the current flows into the condenser, thereby charging it, whereas the condenser is discharged when the contacts close; that is, the contacts short-circuit the condenser and the current that went into the condenser and charged it, now flows back through the contacts. This current may be large and, owing to the resistance of the two contact surfaces produce heat at these surfaces, which tends to weld them together. If, upon opening again, they produce an arc, it will help to burn them clean. When too much condenser is used, the welding action may be sufficiently great to cause them to stick together. It is for this reason that it is advisable to operate with the least possible condenser capacity. If the contacts do not flash over at the maximum exciter voltage without condensers, the regulator should be so operated this way. However, should they flash over, then a small amount of condenser should be used, probably two or three in series where the exciter field amperes are small, in the neighborhood of one or two amperes, while for high field currents, say 10 amperes or more, two condensers should be put in parallel.

### Effects of Too Much Condenser Capacity

A good example of having too much condenser capacity on the relay contacts occurred in a small Eastern town where a regulator controlled the voltage of a small turbo-generator. The contacts stuck on three different occasions, burning out all the street lamps, and every adjustment was carefully checked each time by different men with no better results. However, upon answering the complaint the only work done was to remove all the condensers and the trouble was completely eliminated.

The dashpots should be cleaned occasionally, as they play an important part in the successful operation of the regulator.

The operation of the station with voltage regulators should be the same as when on hand control. Some operators synchronize with the regulators, while others prefer not to do so. This is merely an operating opinion. In all cases, if it is remembered that the regulator is only maintaining a mean exciter rheostat resistance, the same as if the rheostat was turned so only this resistance was in, then the operation is seen to be simple. The regulator cannot accomplish the impossible, but can only place all the resistance either in or out of the circuit, in an attempt to hold the alternating-current at a normal value.



# STEAM TURBINE BLADING

## Westinghouse Reaction Type

*Reaction-type blading of the Westinghouse Electric and Manufacturing Company is characterized by a rigid fastening, secured by wedging or calking at the roots of the blades, as well as the absence of shroud rings. Blades may be assembled with the desired degree of rigidity by suitably tightening the wedges, or calking pieces. Lashing wires locked and brazed to the vanes at intervals supply additional stiffening.*

IN APPEARANCE this type of reaction blading is immediately recognized by the absence of shroud rings. The steam is delivered by the stationary blades at sufficient velocity to enter and drive the moving blades. This expands in the moving blade as well, as explained in the first article of the series,

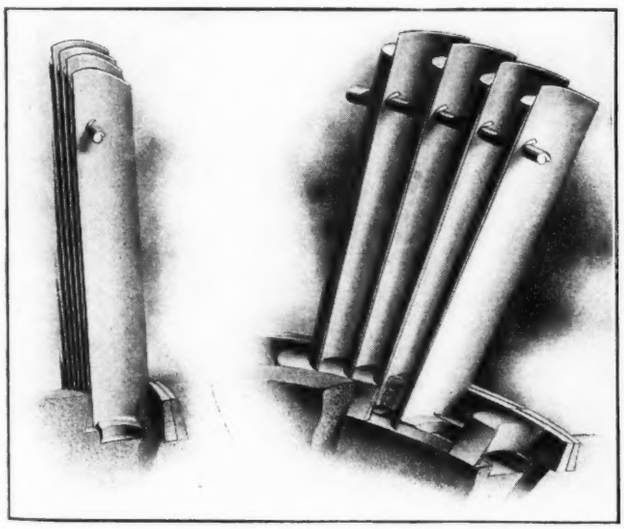


*Fig. 1—Stationary blades held by dovetail calking pieces*

which appeared in the February 5 issue of *Power* Blading of this kind, which is termed "reaction" type, therefore actually utilizes a combination of both reaction and impulse principles, although a large percentage of the driving force is produced by the reaction.

In observing the various illustrations it will be noticed that each blade is thinned out at the top. This is termed "profiling." All the blades are machined in this manner, representing one of the principles laid down by Sir Charles Parsons, the pioneer inventor and manufacturer of this reaction type of turbine, that

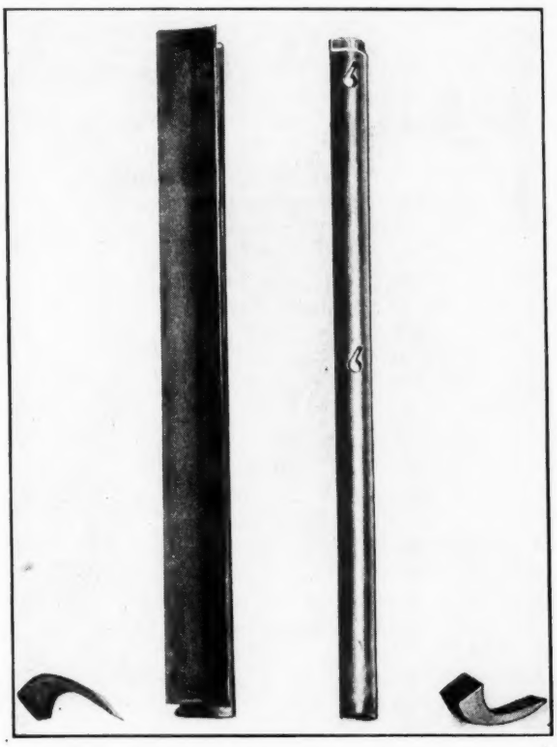


*Fig. 2—Calking strips and wedges secure moving vanes rigidly*

when revolving and stationary parts are adjusted to such close clearances that contact may possibly occur, then either the moving or stationary parts are thinned out to such an extent that rubbing will not produce serious damage. Blade profiling itself was developed by the Parsons Company of England and widely adopted by the Westinghouse Company here. The blades operate with a close radial clearance or in other words, a short distance between the tips of the moving blades and the stationary element, as well as the ends of the stationary blades and the moving rotor body. If contact should

take place, it will result in a small grinding or wearing without appreciable injury to blades or turbine. So little heat would be generated that there is no tendency

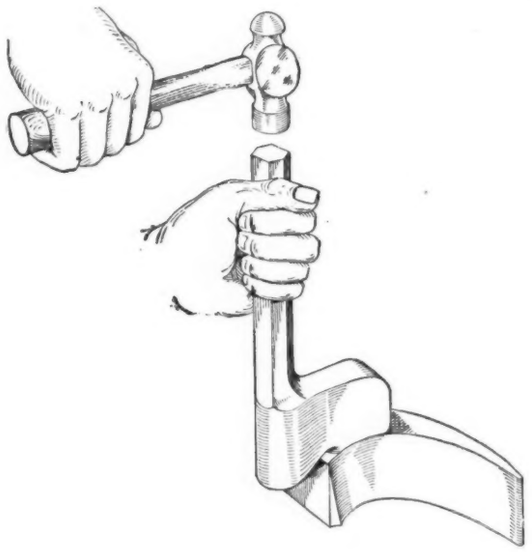


*Fig. 3—Expanding calking piece to fasten blades*

to transmit a sufficient amount through the blades to cause local distortion of rotor or stator.

The use of moderate stresses in turbine blading has always been a feature of Westinghouse construction. On the double-flow turbine large capacities can be built without exceeding safe stresses in the blades; these latter conditions may be obtained by means of the Bauman principle, which also permits the advantage of a single-flow turbine as explained in the article describing the single-cylinder Westinghouse turbine, in the May 15, 1923, issue.

With regard to increasing the efficiency of the blading, two features have been incorporated. One of these is the use of the conical blade passage, which is utilized in the construction of the turbine shown in the headpiece of this article. Instead of using "barrels," or sections of blading of the same diameter containing several rows, it will be seen that each row of blades is of a slightly larger diameter as the steam expands, thus increasing evenly from the inlet to the exhaust. A smooth path for steam expansion is thus produced. It will be noticed that the cylinder surrounding the reaction blades presents a smooth even passage for the steam and is free from the corners which occur in the barrel construction and which produce eddies and friction losses in the steam. A gain in turbine efficiency of approximately 2 per cent has been realized by this construction. The first two blades shown in the headpiece, are impulse blades. The steam is expanded from a stationary nozzle for supplying these. Steam from this stage is exhausted into the remaining blades, which are of the reaction type.

Another means of increasing the efficiency of the larger blades is to change the blade shape or pitch from the root to the tip, so that it will suit the velocity of the steam at each point. With long blades, especially in the low-pressure stages of large turbines, there is an appreciable difference in velocity between the roots and the tips. When a vane is designed for the average velocity with the same pitch throughout from root to tip, steam will pass at maximum efficiency about the middle of the blade. At the tip of the blade, however, the speed of the steam will be somewhat too slow for the blade pitch, and at the root of the blade it will be somewhat too fast. By designing the vane, however, to suit a lower blade velocity at the root and a higher blade velocity at the tip, the entire steam path can be used at better efficiency. This is illustrated in Fig. 5 and will be touched upon in the description of the multi-exhaust blade there shown.

With regard to the mechanical structure of the blading, there are three outstanding features designed to secure rigidity and prevent blade vibration. In the first place the moving blades are tightened into the rotor, by means of wedges driven up by a hammer. In the case of large blades two sets of wedges are used. Secondly, the bases of the large blades, which contact with the rotor, are broadened much beyond that of the usual design and gradually taper toward the top. The use of a tapered blade restricts blade vibration, as it represents a stronger mechanical element, and also from the fact that a body that is broad at the base and narrow at the top has less tendency to vibrate due to its own period of vibration, than one that is of the same length and a uniform section throughout, according to the usual blade design. A third method of securing rigidity is by the use of lashing wires. These

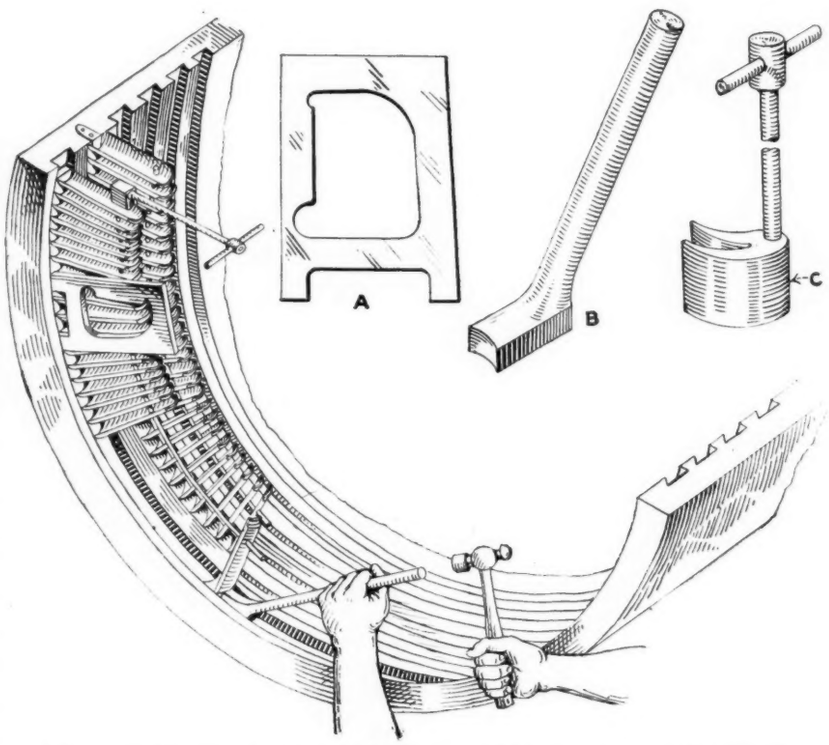



*Fig. 4—Stationary vanes quickly assembled and accurately gaged*

are attached to the vanes at intervals of about six inches from the base to the tip, passing through holes in the blades. They are brazed on both sides, thus securing groups of blades into integral structures.

The stationary blading in Fig. 2 is not subject to the rigorous conditions of moving blading, as explained in the first article of the series. These are not wedged, but are held in place rigidly by calking. The soft metal

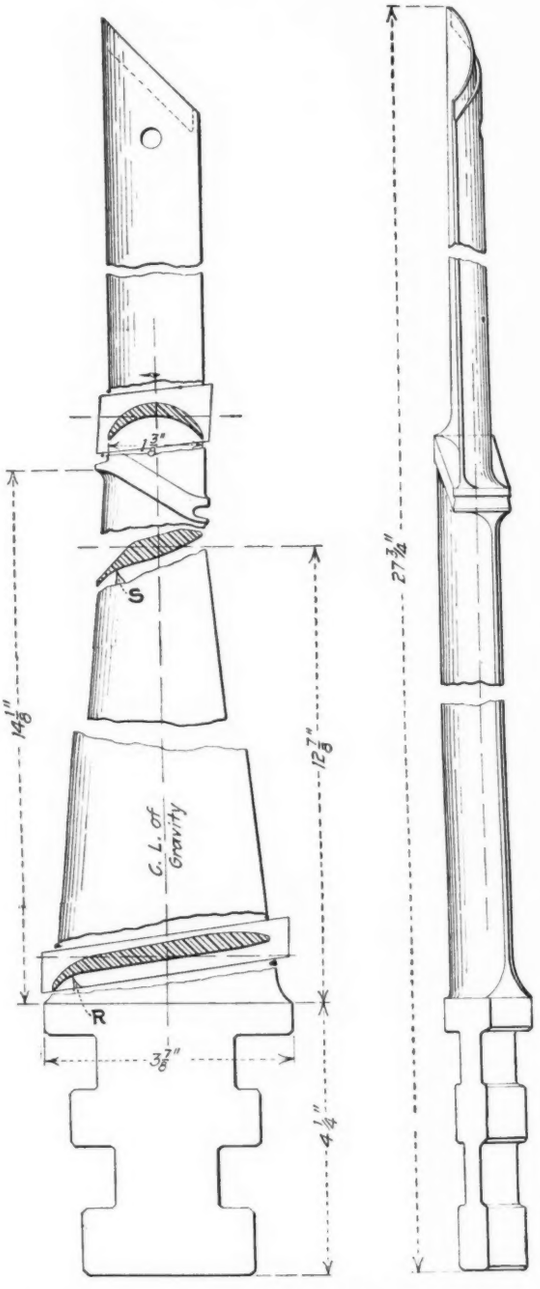



*Fig. 5—Forged steel multi-exhaust type moving blade*

calking pieces are indicated at the lower part of the figure. The packing pieces do not have dovetailed sides.

The moving blades shown in Fig. 1 are fastened by means of dovetailed spacing pieces, wedges and lashing wire. Blades more than three-quarter inch long are wedged, shorter lengths are fastened like stationary vanes. The "comma" lashing wire is named from the shape of the cross-section and is used to stiffen the blades. This may be partly sheared and bent over on each side of the blade as shown, leaving a construction that keys the blade in place, preventing it from moving in either direction along the comma wire. The wire, in addition, is brazed on both sides of the vane. Large moving blades, like those of the multi-exhaust type shown in Fig. 5, are fastened with two sets of wedges.

Stationary vanes may be quickly installed and then accurately gaged, tested and set, as indicated in Fig. 4. Each blade is set in place and then a soft calking piece added, which keys it into position, then a second blade is added, etc. After a row of blades have been assembled in the stationary element, they are tested for a radial position by means of the radial gage shown at *A* and adjusted. The twisting tool shown at *C* and also at the left of the figure, is used in placing the blades in a proper position, so that they will correspond with the radial gage. After the blades are properly gaged, they are calked securely by means of spreading the calking strips. Fig. 3 shows the spreading of the calking strips by the use of a hammer and calking tool. This fastens the stationary blades rigidly. It will be noticed that the calking strip is of dovetail construction, therefore dovetailing the blades in place. The comma wire is then fastened by driving down and shearing the edges on each side of the vanes as before mentioned, and the blades are then brazed. On the flat joint surface of the stationary element a clamp or stop is fastened, which secures the end of each blade row, holding the row in place. This stop prevents crowding of the blades beyond the joint surface.

### How Moving Blades Are Installed

Moving blades are installed similarly to the stationary, except that wedges are added. The wedges are tightened by hand driving, as Fig. 6. The driving tool is similar to *B*, Fig. 4. For very long blades, especially where two sets of wedges are used, a light sledge hammer is utilized in order to produce sufficient wedge pressure. After the blades are gaged, the comma wire is set and brazed as in the case of stationary blades. The soft calking strips are afterward spread somewhat with a calking tool.

In order to strip the blades from the rotating element for the purpose of reblading, it is necessary first to cut out a few blades, drilling into the roots to some extent and removing the blading material and wedges with a cold chisel. After this operation is done, it is a small matter to knock out the wedges of the remaining blades and replace with new material as desired. A similar treatment makes it possible to remove the stationary vanes readily.

The principle of the multi-exhaust blading has already been explained, as previously mentioned. The details of a long blade are shown in Fig. 5. This represents a moving vane. The lower part bypasses steam to a considerable extent, allowing it to do little work. The upper, however, is proportioned to extract a normal amount of work from the steam. The expansion is here designed to take place in a much greater degree; more speed or velocity is extracted from the steam, as indicated by the more acute angles seen in the upper section.

In the lower section, Fig. 5, there is a smaller radius at *R* than at *S*. The velocity of the blade is smaller at *R* since it revolves around a smaller radius than at *S*. In order to extract the same amount of velocity from

the steam, which moves at a fairly uniform speed, the angle at *R* is made closer to the axis of the rotor. In other words, the steam is "bent" more at the base of the blade, so as to absorb more driving power from the steam discharged.

The lower part of the blade is approximately four inches wide and the top about half this amount. It can be seen that the section of base of the blade is very thin in proportion to the width, so that a maximum distance between blades is obtained for the passage of

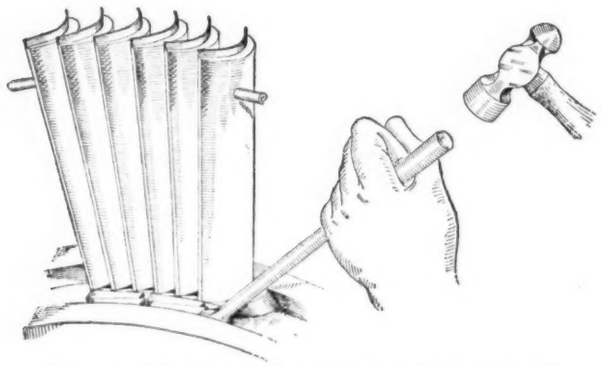


*Fig. 6—Wedges fasten moving blades rigidly*

the steam. This gives a comparatively greater area for admitting steam between the blades, as contrasted with the usual design of vanes, which must have a thicker cross-section on account of being narrower at the base. The thickness of the blade increases from the root to the first barrier. This is a division between the upper and lower sections. From this barrier to the tip of the blade, however, the thickness decreases to some extent. The blades are forged from a special grade of electric furnace steel.

## Keeping Generators in Service When Trouble Occurs on the System

By C. M. King

Despite the advances made in the design and application of protective relays, some transmission systems are operated without relay protection in so far as the main high-voltage lines are concerned. It may be said that substation feeders are invariably protected by fuses or relays, and although faults occurring on long, high-voltage lines cannot be located and cleared nearly as quickly by manual switching as by the functioning of relays, circumstances sometimes make it advisable to operate such lines without relay protection.

When a fault occurs on a system where relays are not used, it is either burned clear, the defective section is switched out manually by the operator, thereby clearing the trouble, or the system is manually separated, usually with a generating station connected to each section, in which case the trouble is localized, being finally cleared by switching out the faulty line.

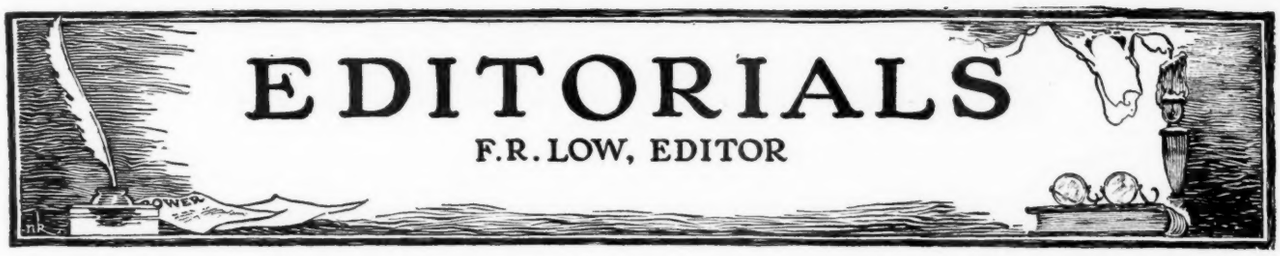
Transmission-line faults are generally of such nature as to cause a sustained flow of current at least 200 per cent of the full-load rating of the generators, it decreasing, after one or two seconds, to this value from a maximum of probably 600 per cent of full-load current. If the impedance of a fault and the intervening circuit is so low that the generator voltage will be greatly decreased, the generators will probably fall out of step, but they may quickly return to synchronism if the trouble is quickly cleared.

Since the armature current of a short-circuited generator is nearly directly proportional to the field current, where generator-voltage regulators are employed the short-circuit current may be 20 per cent greater than when regulators are not used, for the low voltage that accompanies a short-circuit will cause the voltage regulator to increase the exciter voltage and the generator field current to a high value. Owing to the inductance of the windings of generators and exciters and the dampening effect of the regulator dashpot, a few seconds may be required for the field current to reach its maximum value; and if a faulty transmission line is switched out when the generators are fully excited, the generator voltage will be excessive during the time required by the regulator to reduce the excitation to the no-load value. While this increase in voltage is most pronounced where a regulator is employed, the voltage of generators under hand regulation will increase if, as is generally the case, the excitation is in excess of the no-load value when the short-circuit is cleared. Hence, before separating from a faulty line, it is advisable to reduce the generator voltage, especially where there is a possibility of the generators' overspeeding, and it is apparent that if the short-circuit clears before the line is switched out, the voltage, especially at the receiving end, may attain a dangerously high value.

If the line is long or requires appreciable charging current, it is necessary to connect it at low voltage, for not only will the leading charging current increase the generator voltage, but the compounding effect of the leading current flowing through the inductive transmission line will cause the voltage at no load to be higher at the substation than at the generating station. In a plant where a 22,000-kva. generator was used to charge a 200-mile line, the generator voltage increased from 4,000 to 8,000 volts, the field current remaining unchanged, when the generator oil switch was closed, indicating 100 per cent increase in voltage at the generating station because of the magnetizing effect of the leading line current.

The voltage is reduced by cutting in the exciter or generator rheostats, and in one large plant, where each generator is excited from a motor-driven exciter, special shunt field rheostats are arranged for simultaneous operation by being connected to a motor, which is controlled from the switchboard. In order to avoid the delay introduced by the electrically controlled generator field rheostats, in one large plant resistance, normally short-circuited by a field breaker, is connected in series with each rheostat, and the voltage is quickly lowered by opening the short-circuiting breakers, each of which can be controlled individually or from a master bus. In a plant having the right-of-way over a line 200 miles in length, the generator voltage can be reduced to zero by opening a small switch connected in series with the main contacts of the voltage regulator.

A Correction—In the discussion on "Coal Storage Systems," *Power*, Jan. 29, the statement was made that a drag-scraper system to handle 60 tons per hour would cost $15,000. In this statement the costs of bunkers and elevating machinery were included, and attention has been called to the fact that the scraper system complete can be installed for $6,000.




## Visiting Old Plants

OPERATING engineers are more and more being accorded opportunities to visit new generating stations within reasonable distances of their own "home towns" as progressive executives realize the benefits to be derived from observation and personal contact in different installations. It is a mistake, however, to fail to visit even older plants that are still in operation, if the engineer finds himself in a position to do so. Interesting as are new stations representing the last word in heat-balance control, segregated phase construction, powdered-fuel equipment, or other features much talked about today, it is equally profitable to inspect sympathetically the older installations, to study the difficulties encountered by their operating engineers in long years of service and to compare improvements, whether realized or potential, with conditions in one's own station.

Behind a very unpromising exterior often lie problems of great operating interest. Rare indeed is the plant visited by a member of the editorial staff of *Power* which has nothing unusual in its operating problems, equipment arrangement, maintenance practice or otherwise.

Pass not by on the other side when you are tempted to look askance upon a costly and useful assemblage of faithfully operated machinery on your way to admire the latest fashion in power-plant design, but at least give "the old junk-pile" the "once over" on the chance that you may both learn and impart something as a result of your visit.

## A Familiar Situation in Plant Design

THE designing engineer of a power plant usually recommends or specifies the material to be purchased. His plans, however, frequently depend on the condition of the business or industry the plant serves.

At the last minute an unexpected reason for economy may arise and prevent their complete fulfillment, or, on the other hand, as more frequently happens, he may be asked to provide for double the expected capacity. In either case the burden of readjustment falls on the shoulders of the engineer.

After experiences of this kind he is frequently on the alert to sense such possible situations. He may not be in a position to combat these conditions directly, but often there is an inclination to find ways and means of preventing, or at least alleviating, the ill effects of expected irregularities.

It is customary in some quarters to provide for more than the desired capacity, so that if the need of an increase should occur at the last minute, plans would be immediately available.

In one instance the electrical equipment of an industrial plant, with an ultimate capacity equal to that of a fair-sized central station, was being laid out. In planning the distributing station, switches and conduits were to be allowed for a number of active switches as well as an equal number of conduits for future equipment. In anticipation of a wave of economy which would probably sweep aside future considerations, the designer saw to it that the conduits, both for the present and the future installation, were laid out, installed and concreted over in a much shorter time than usually anticipated.

However, business conditions soon required that the provisions for future equipment be eliminated. This proved to be too late for their being carried out. Some time afterward the engineering department was asked to determine the most convenient method of installing an additional number of switches, which would be needed in accordance with later plans. This would ordinarily have required the breaking up and relaying of much concrete. On being advised of the true condition of affairs, there appeared to be no ground for criticism, and there remained the satisfaction of making a cheaper and better installation than would otherwise have resulted.

## A Wide Divergence in Hydraulic-Turbine Design

AT THE end of last year one of the leading American manufacturers of hydraulic turbines, when commenting upon the hydro-electric developments during 1923, made the statement, "The fourth unit for the Long Lake Station of the Washington Water Power Co. was built last year. It is similar to the three existing units, being of the horizontal-shaft, double-runner type with double intake and single discharge, and is being installed in an existing setting. It has a rated capacity of 22,500 horsepower under a head of 168 feet. The fact that this is the only horizontal unit that has been built by this company for several years shows clearly how completely the horizontal-shaft type has been replaced by the vertical-shaft single-runner type in all new installations." The reports of extensions being made in other stations with vertical-shaft Francis units in which horizontal-shaft machines were originally installed is further verification of the foregoing statement.

In the light of these facts the leading article in this issue, which describes the Raanaasfoss power station in Norway, will be of interest to American readers. Those familiar with the almost universal adoption in this country of the vertical-shaft reaction-type turbine for all important installations for heads up to over eight hundred feet will wonder why in Europe horizontal-shaft machines should be installed in one of that continent's most important installations. In this country the vertical-shaft Francis-type units have become well standardized as to the general design of the machine and arrangement of parts. The remarkable operating records of efficiency and durability of these units have well justified the engineering judgment that led to adopting this design.

In the Raanaasfoss plant two different European manufacturers supplied the turbines—one Swedish, the other German. The machines are of the double-runner horizontal-shaft type set in an open flume and discharge into bent-type draft tubes and are rated at twelve thousand horsepower at one hundred and seven revolutions per minute under a forty-foot head. No such a standardization in design of these units can be found as exists in the vertical Francis type in this country. In three of the machines supplied by one manufacturer a very large shaft is used without an intermediate bearing between the runners, giving a total length between bearings of forty feet. In the other three machines a small-sized shaft is used with an intermediate bearing. The regulating mechanism on one design is inside the flume, while in the other it is on the outside. Although the same kind of construction is used in both types of runners in so far as the buckets are concerned, different methods have been employed for mounting them on the shaft. The runners are made with buckets of plate steel cast into a band and a hub of cast steel, in contradistinction to the cast runners that are almost universally used on all important turbines built in this country.

One of the widest divergences in construction exists in the draft tubes at the discharge from the runners. In one design the usual form of bent tube is used, while in the other baffles are installed which divide the discharge from the turbine into four sections. Tests made in this country on models, show that baffles in draft tubes are detrimental to efficiency. It may be possible to place a baffle in the tube so as to be of advantage at one point in the load, but at any other load the efficiency will not be so good as without the baffle. The fact that the turbines with the baffles in the draft tubes developed about five per cent lower full-load efficiency than the units without baffles in the draft tubes would seem to bear out the results of these tests, although a somewhat better part-gate efficiency was obtained with the baffled tube. A slight misplacement of the buckets in the molds, given by the engineers as the cause for the lower efficiency, does not seem to be a satisfactory answer in the light of the experience in this country with baffled draft tubes.

Taking the design as a whole, one cannot help being impressed with its complication, particularly from an operating viewpoint, when compared with a modern single-runner vertical-shaft design and no doubt a question will be left in many American engineers' minds whether the design was justified on the reasons given, namely, that it was the least expensive and was best suited to the space limitations.

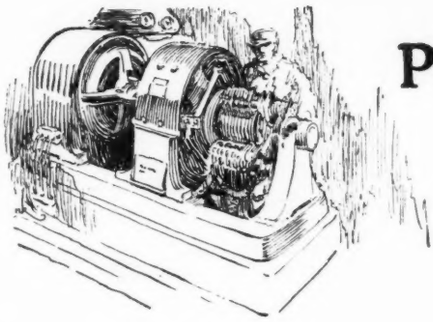
## Stabilizing the Coal-Mining Industry

AS THE time approaches for a new agreement between the bituminous-coal operators and miners, the possibilities of a satisfactory settlement look promising and the likelihood of a strike diminishes. According to the leaders of the miners they will ask a renewal of the present contract for several years. If for no other reason than to give the coal industry an opportunity to become stabilized, this offer should be accepted by the operators. Although the country has in storage or will have by April first sufficient coal, when combined with that from the non-union bituminous mines and a greater use of anthracite and oil, to stand a strike for six months or longer, a test of strength between the operators and miners is one of the last expedients desired. John L. Lewis's statement that the coal industry must make a "sincere effort to place its house in order," is one of the most encouraging statements that have come from either operators or miners for a long time.

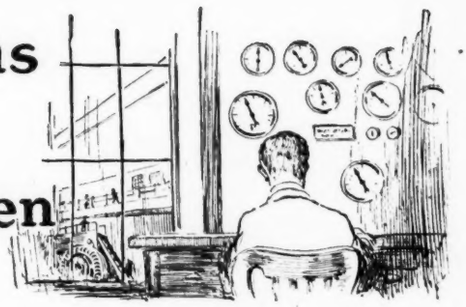
The coal industry through overdevelopment has been placed in an extremely difficult position. Even with the inefficiency that exists, there are about two hundred thousand more miners than are required to mine the country's coal. In 1918, which was the peak year in bituminous-coal production, there was produced in this country five hundred and forty million tons. Since that time production has fallen to about four hundred million tons, as for 1920. Last year's production came back to near that for 1918, but about eighty million tons of this went into storage, so that it can be safely said that the coal-consuming capacity of this country is less today than in 1918. During this period the heating and power requirements have greatly increased and continue to increase.

There are, however, a number of factors that are operating to hold the coal consumption practically constant. Remarkable improvements are being made in both central-station and industrial power-plant efficiencies. It is not an uncommon occurrence for a large industrial plant to cut its coal consumption as much as fifty to sixty-six per cent, making savings up to fifty thousand tons per year for the same quantity of manufactured products. In the steel and allied industries tremendous savings in fuel are being made by a more efficient utilization of waste gases and heat. By improved manufacturing methods the cement industry is cutting in half the fuel required to produce a barrel of cement. H. A. Schaffer, conservation engineer, Portland Cement Association, recently made the statement that when all the companies in the association have completed the improvements that are now under way in the conservation of heat, they would result in an annual saving of two million tons of coal. The greater use of fuel oil under boilers and in oil engines both in marine and stationary practice has cut heavily into the coal consumption of this country. The rapidly increasing use of water power is having a very marked effect in keeping down coal consumption. This is true not only in this country but also in Canada, particularly in those provinces depending largely upon the United States for their coal supply.

In the central stations not only have improvements been made in design and operation that have assisted materially to keep down coal consumption, but interconnection of systems has allowed a more efficient use of water-power plants and the operation of steam stations in a way to reduce the coal consumption per unit output. The greater use of low-grade anthracite has also contributed its share. These and other factors are working to prevent the coal-mining industry from absorbing its overdevelopment as other industries have done since the close of the war. The possibilities of keeping down our coal consumption by more efficient methods of utilization and a greater use of water power have by no means been exhausted, and the next decade should see even greater progress than any preceding ten years. These are some of the facts that the bituminous operators and miners must face when they attempt to stabilize their industry, and these do not look favorable for absorbing the production of two hundred thousand excess miners.

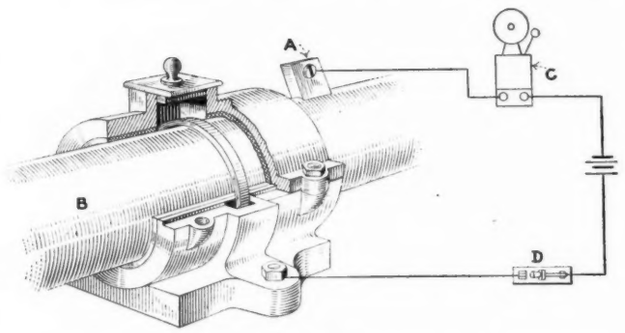


# Practical Ideas *from* Practical Men



## Testing the Effectiveness of Bearing Lubrication with an Electrical Circuit

The device shown in the illustration was used some time ago in a power plant to test the effectiveness with which several different kinds of oil lubricated a bearing that had been causing trouble. The brush *A* was placed in contact with the rotating shaft, which had been




*Arrangement of bell circuit for testing effectiveness of lubrication*

cleaned previously in order to insure good electrical contact. This brush was connected to one of the binding posts of an ordinary electrical door-bell. The other binding post of the bell was connected to the lower part of the bearing pedestal, with two dry cells and a switch interposed in the line.

Oil is, of course, a fairly good insulator, and a very thin "film" of it will break a circuit of such a character as the one shown. Since the purpose of oil in the bearing is to reduce friction and wear to a minimum by placing between the metallic surfaces a film of oil, if this film is complete and no metallic contact occurs, the electrical circuit should remain open as long as the shaft is revolving.

The point of contention was whether a heavy oil was better than a light oil for this particular job. The heavy oil was first put into the bearing and the switch *D* closed. The bell began to ring vigorously, showing that a complete circuit had been made. The shaft was then rotated at the normal operating speed and under normal conditions of load. After half a minute had elapsed, the bell ceased to ring constantly and finally rang spasmodically at considerable intervals.

The light oil was then substituted, the bearing having been completely cleared of the heavy oil. The switch *D* being closed, the bell rang vigorously as before, but when the shaft was set in motion under the same conditions of speed and load, the first few revolutions of the shaft served to quiet the bell entirely, nor did it ring again until the rotation of the shaft had been stopped and the pressure of the shaft had squeezed out the film of oil.

The device showed plainly that the heavy oil formed its film slowly and also that it did not maintain it constantly, there being metal-to-metal contact at times. In the second case it proved that the light oil was superior, that it formed a film quickly and was fluid enough to keep a constant film between the shaft and the bearing surface.

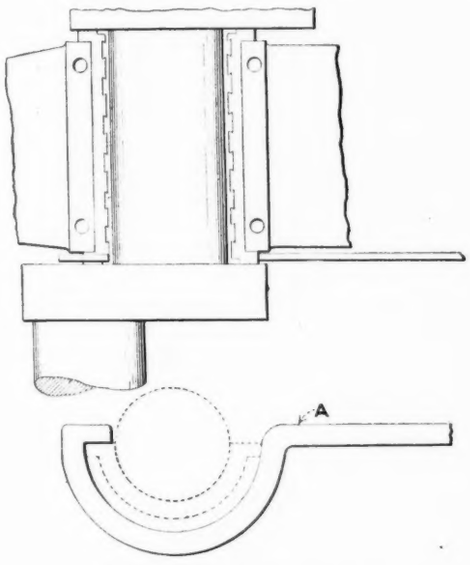
The same results could have been attained only by long and expensive trials of both oils, which would have resulted in conclusions based on the conditions of the bearing surfaces after extensive use of first one oil and then the other.

WILLIAM V. FITZGERALD.

New York City.

## Breaking Crankshafts

The breaking of oil- or gas-engine crankshafts is due in most cases to the poor alignment of the shaft. To avoid trouble the alignment should be checked at least once a year and the shaft examined carefully with a powerful magnifying glass. Kerosene should be applied freely and then wiped off and a light coat of




*Wrench for shaft bearings*

Prussian blue smeared on. When the engine is barred over, the kerosene will work out of the fracture and be clearly indicated on the Prussian blue.

If any of the bearings are to be removed, make a wrench of the best steel procurable and narrow enough to pass between the crank web of the frame and the

bearing so that the wrench lip can engage the top of the bearing as shown in the illustration. Next ease the shaft with a jack-screw to relieve the weight and apply enough power on the wrench to turn the bearing over. If a bearing rolls out when turning the crankshaft over, it is evident that the friction between the bearing surface and the journal is too great and the bearing should be taken out and eased slightly across the jaws, and the trailing side of the bearing should be well beveled off to allow the shaft to draw in as much oil as possible. This, of course, should not extend farther than one inch from the ends of the bearing shell, or the oil will flow out.

Large engines have the main bedplate made in two or more sections and these connected together by a number of bolts in the interior of the base. In the erection of this type great care must be taken to see that these faces are free from any burs and perfectly clean. The bolts joining the piece together should be tried by tapping them with a hammer, which will denote their tightness. This joint will have a tendency to open and close should the shaft be out of line or if the face of the couplings in a two-piece shaft be out of truth.

On one occasion I pointed this out to the superintendent of a plant and advised him to relieve his shaft at once. Some months afterward, on learning that the shaft had broken and had wrecked the engine, a special visit was made to look over this wreck. It was found that this crank nearest to the center coupling had given way, fracturing the center bearing. On making further inquiries, it appeared that although the engine had been in operation for several years, the shaft had never been realigned. I was informed that the main base was to be shipped away to be welded, as an end lip of the bearing housing had been broken off. This would require tearing out the engine-room wall to get out the casting. This expense was unnecessary, for the break could have been welded at a slight expense.

New York City. H. T. MELLING.

## Home-Made Cylinder Head Gasket

On being called upon to make an inspection of a 600-b.hp. Diesel engine, it was found that one of the cylinder-head gaskets had been so badly damaged that no further use could be made of it.

As the engine was of foreign manufacture and required for immediate service, it was necessary to devise a gasket that would stand up to the high pressure and conform with the standard thickness so that the maximum compression pressure could be obtained.

The gas seal was obtained through a tongue on the cylinder head and a groove on the cylinder top flange, the gasket resting in the groove.

A supply of light ⅜-in. copper tubing was in stock, and a length was cut off equal to the circumference of the groove plus two inches for the overlap. The tubing was then annealed and bent round to fit the recess, the ends being cut away to form the lap joint. To hold this joint in position, it was necessary to tin the edges overlapping each other and sweat the two sections together with soft solder.

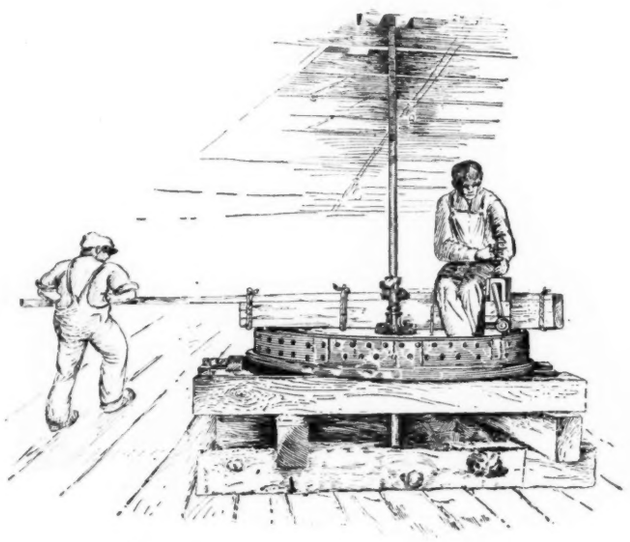
After the cylinder head had been tightened down, it was again lifted to examine the overlap, which was found to be satisfactory, the ends of the copper being forced together so that it would have been impossible to detect it, had not the location of the joint been marked on the liner.

The satisfactory operation of this type of gasket combined with its slight cost made it a standard practice in the plant for all cylinder-head joints.

New York City. T. MELLON.

## Machining a Flange Under Difficulties

Recently, it became necessary to rivet a cast-steel flange to a 66 in. welded penstock to permit the insertion of a butterfly valve. Measurement of the flange upon arrival indicated that its inside diameter was about ⅜ in. less than that specified, hence the only course was to bore it out. The usual procedure would have been to ship the flange to the nearest shop having facilities to machine a casting of this diameter, which in this case was 150 miles distant. However, it was necessary to complete the installation of the butterfly valve within



*Method of boring out flange*

a limited period, so rather than risk a possible delay due to shipment, it was decided to do the machining in the field.

As shown in the figure, a boring rig was made by placing the flange on a rough crib frame constructed of heavy timbers. A section of 2-in. shaft was placed vertically within the flange and securely clamped at the top and bottom. Two bearings were bolted to an 8x8-in. timber and clamped about the shaft, and two iron plates screwed to the timber were utilized as thrust bearings, the weight being supported on the upper edge of the flange, which was kept well oiled.

The toolholder of a lathe was bolted to the 8x8 in. timber. This arrangement held the tool rigidly, but it was necessary to place 200 lb. of iron on the timber to keep it in contact with the upper edge of the flange. The machinist was stationed at the carriage and regulated the feed of the tool as the timber was revolved by four laborers, two of whom worked at the end of each wooden lever secured to the timber.

Although the utilization of man-power for revolving the cutting tool was not desirable, it was more economical to follow this unusual method than to arrange for motor drive, and the flange was made entirely satisfactory for the purpose intended. RALPH BROWN.

Caribou, Calif.

# Comments from Readers

## Where Should the Water Be Discharged in a Return-Tubular Boiler?

Referring to the inquiry of R. E. Graves in the Jan. 29 issue, "Where Should the Water Be Discharged in a Return Tubular Boiler?" I will mention the following experience:

I had charge of two 500-sq.ft. return-tubular boilers that persisted in leaking at the girth seams below the water line. Chipping and calking would not stop it, and after a number of rivets had been cut out and replaced, the joint continued to leak. These boilers were fed through the blowoff pipe. A new feed pipe was installed and located as follows: A hole was drilled through the shell near the top manhole and was tapped from the inside. An extra-heavy nipple was screwed in and connected to an angle valve on the outside. On the inner end of this nipple a 45-deg. ell was used to carry the pipe to the right-hand side of the boiler, thence to a point near the front head. A 90-deg. ell was then used to carry it to the left-hand side, thence to within 15 in. of the rear head. It was then carried to the center and down through the central space to within 12 in. of the shell, making 28 ft. of pipe through which the feed must pass before it was discharged. The open end was so far from the shell that sediment could not lodge at any special point. This entirely eliminated the trouble, and the job was completed by three men in 14 hours.

Four of the boilers in my present plant were piped according to the usual practice as follows: The feed pipe passes through the front head above the tubes, is carried to within 12 in. of the rear head, thence to the other side, where it terminates in an ell looking downward. I had the latter pipe shortened until it discharged above the central space between the tubes. The more important feature of this is that it terminates in a tee instead of an ell. The side outlet of the tee is screwed onto the pipe, therefore the discharge is "fore and aft" instead of downward. Furthermore, the speed of discharge is one-half of what it was formerly.

New Haven, Conn. W. H. WAKEMAN.

## American and European Hydraulic-Turbine Practice

I would like to say a word regarding your editorial "Both Have Much to Their Credit," in the Dec. 25 issue.

There have never yet been carried out in Europe any actual propeller-type hydraulic-turbine installations involving a unit of large capacity, and both European engineers and some American engineers have been on record to the effect that the propeller-type units are not applicable to heads of over 30 ft. It seems to me that, from a disinterested point of view, an installation such as the 28,000-hp. units to operate under a head of 56 ft. in the Great Falls plant of the Manitoba Power Co. should be regarded as a large step in advance in turbine practice. In your editorial you appear to be greatly impressed by a proposed new method of regulating turbines by means of a submerged operating mechanism contained within the rotating element, and that you consider this one idea sufficient to overbalance all the notable work done in this country in the last few years is apparently indicated by your statement that "This is one of the cases where development has shifted in favor of Europe almost over night."

In view of the unwillingness of European engineers to apply the propeller-type turbine to any heads except of very low values and the strong probability that the adjustable-blade runners will be limited to a still lower range of heads and probably to small installations unless in exceptional cases, and furthermore that the device still remains to be tried out under the severe conditions of commercial operation, I fear that your editorial has given an impression that is not justified.

Those American engineers who have visited Europe in the last few years and have investigated turbine practice there are greatly impressed by the tremendous strides made in this country and with the backward state of the art in Europe, and it will require more than one or two innovations of the kind which you mention to overbalance this.

I also question whether the origin of the propeller-type turbine is to be credited to Europe. Our own Patent Office contains a large number of American patents involving propeller-type turbines. Kaplan made certain advances in developing this form of turbine, but I feel that the development in this country has been even greater and that we have outdistanced Europe in placing this type in the engineering practice of the day. H. BURCHARD TAYLOR, Vice-President,

Wm. Cramp & Sons Ship & Engine Building Co.
Philadelphia, Pa.

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At the time of the starting of the Keokuk plant, the *Engineering Record*, page 533, Nov. 16, 1912, in commenting on the event stated in an editorial: "While the best skill and data in this line are found in European practice, it is no small triumph for American engineers that have so applied experimental knowledge as to obtain in working units the highest efficiencies to date for turbines of this character."

Europe was then barely aware of the development of this new type of single vertical machine and had not built anything even remotely approaching the Keokuk units in size, nor have they done so now, ten years later. At the same time America held and had held for practically the entire history of the development of modern waterwheels, all records of head, horsepower, physical dimensions and efficiency. Furthermore, America had originated and perfected both of the types of waterwheels now universally used. These are the impulse, or Pelton, type and the Francis, or reaction, type, over 90 per cent of the world's horsepower being developed with these two types. Incidentally, it took Europe twenty or thirty years to adopt these two types, having

previously for the better part of the century adhered rigidly to various other types, which have since been completely discarded.

What we wish to deplore is that an editorial in a leading American technical journal could be so thoroughly saturated with European propaganda and show such unfamiliarity with the facts of the case, as to make the statement quoted.

The occasion for this letter is the editorial, "Both Have Much to Their Credit," on page 1034 of *Power*, Dec. 25. The situation that existed at the time of the *Engineering Record's* article exists to a much greater extent today and all of the foregoing remarks apply with added force to your recent editorial.

We would not detract in the least from credit due European designers for what they have accomplished. We are glad that American engineers have been able to show them the best type of waterwheels, the Pelton and Francis. We are glad that we have set the pace in efficiency for at least half a century. We take no particular credit for having built the machinery for over half the water horsepower of the entire world. We might even regret that we happen to have built units over three times as large as the largest they have produced and have held the record for capacity for nearly twenty years. All this is in a spirit of fair play. What we do wish is that our technical journals would at least present the matter fairly to the American public.

The so-called propeller-type runner evidently was original with European engineers as it was with us and even granting that they antedated us, it is a matter of record that its principal development and application have so far been in this country. Our own company has built and installed bigger units, more efficient units and many more units of this type than all European builders together. This is apparently grudgingly conceded in your editorial, but it is immediately discounted by reference to installations that are as yet on paper only. The numerous installations, the capacity of which is emphasized graphically in Mr. Engelson's article in *Power* for Nov. 13, 1923, that apparently prompted your editorial, are hardly past the drawing-board stage, and there is certainly no operating data on any considerable unit embodying the features in question. Our own development at Green Island has not even yet been approached by Europeans except that they send men over to copy it, still when it was written up in *Power* a year or so ago, it called for no special editorial eulogies.

We take particular exception to the closing sentence of your editorial. The fact of the matter is that European builders are now able and for twenty years have been able to lay down turbines in this country or in other countries at prices ranging down to one-half ours. In spite of this fact and in the face of the loyal support of American technical journals, there are practically no European turbines in this country. Furthermore, American manufacturers are called upon more and more to bid in foreign markets for the largest and most important machinery. For example, we sent to Japan, during the last two years, turbines aggregating perhaps half a million horsepower capacity, these covering most of the large and important plants for that country. This is cited merely as a comment on your closing sentence.

It is a fact that practically no European turbines come to America and this is for the very good and sufficient reason that they cannot compete with us in quality from either a mechanical or a hydraulic standpoint. They have been repeatedly tried, but seldom twice in the same place. Their price advantage would more than offset our advantage of nearness to the market. On the other hand, we are continually and increasingly sending turbines into markets that were formerly exclusively theirs.

W. M. WHITE,
Manager and Chief Engineer,
Hydraulic Department,
Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

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[We hold no brief for European engineers except to attempt to be fair in giving due credit for what they have contributed to the art. If we have erred it has been in a spirit of honest endeavor to give the fellow who is not one of us all that is his just due. In spite of Mr. White's accusation that we are thoroughly saturated with European propaganda, in the spirit of fairness we still maintain that even down to comparatively recent date European engineers have exerted an influence in hydraulic-turbine design in this country. For example, if *Engineering Record*, March 15, 1913, is correct, European engineers were not excluded entirely from the design of the Keokuk plant. When those responsible for the development of Keokuk were considering turbines for this development, specifications were sent to prominent manufacturing companies both here and abroad and a prize of $5,000 offered for the best design. Originally, it was expected that a double-runner wheel would be used, but an alternative was provided in the specifications for a single-runner machine. When the proposals were received, four were from American and one each from Swiss, German and Swedish manufacturers. All the American designs were in favor of the single-runner type, but although the foreign firms submitted single-runner designs, they did not believe any foundry would undertake to make the castings.

None of the designs that were considered was satisfactory, so that the power company called in an eminent Swiss engineer and with his assistance the general design for a single-runner turbine was worked out and given to two American turbine manufacturing companies to work out the details and build the turbines. Keokuk is one of at least three plants that operate under similar conditions and have vertical single-runner units of approximately 10,000 hp. The other two are the Cedars plant on the St. Lawrence River near Montreal, Canada, and a station of recent construction on the Volhov River about 75 miles from Petrograd.

As to Mr. White's statement that American waterwheel manufacturers have built machinery for over half the water horsepower in the world, it is of interest to know that of the 26,000,000 water horsepower installed in the world over 14,000,000, or 54 per cent, is in the United States and Canada. The largest-capacity turbine units in Europe that we have any record of are those in Norway on the Glomfjord, two of which are rated at 25,000 and one at 27,500 hp. These are Pelton-type wheels operating under a head of 1,450 ft. As for the turbine described in the Nov. 13, 1923, issue of *Power*, although this will not be in operation until about the middle of this year, units of a smaller size are in operation.

In spite of what Mr. White may say about sending to Japan, "during the last two years, turbines aggre-

gating perhaps half a million horsepower capacity," it does not alter the facts given in the editorial that "practically no European turbines come to America and the same is true of American turbines going to Europe."

It must be conceded that the turbines Mr. Taylor refers to are a large step in advance in turbine practice. Although no information is available at this time on the turbines operating under full head, they have been operating for over a year under heads varying from 18 to 47.5 ft. during the completion of the dam. Under the latter head they have developed 24,500 hp. and operated in a manner showing that the full expectations of the designers will be realized.—EDITOR.]

## Early Corliss Pumping Engine

In the issue of Nov. 6, 1923, W. E. Hopkins presents some details of the early pumping engine built by George H. Corliss in 1878 for what is now the city of Pawtucket, R. I.

It occurred to me while reading this letter that a view of this engine would be of considerable interest to readers of *Power*. After making several inquiries, I obtained from A. H. Keene, chief engineer, Department of Public Works, City of Pawtucket, R. I., the photograph shown in Fig. 1, also a copy of a paper presented by Prof. J. E. Denton at an A.S.M.E. meeting in 1889, from which the cross-sectional view shown in Fig. 2 has been taken. Mr. Keene also contributed the following information:

The engine is still in excellent shape and is held as a reserve pumping engine, and is ready to start within a few minutes' notice.

The steam-jacket on one of the cylinders cracked a few years ago, so it was considered unsafe to carry 125 lb. pressure.

About eighteen years ago, we connected these jackets up with the condenser, thereby creating a vacuum in the jackets. The crack in the jacket was repaired by painting

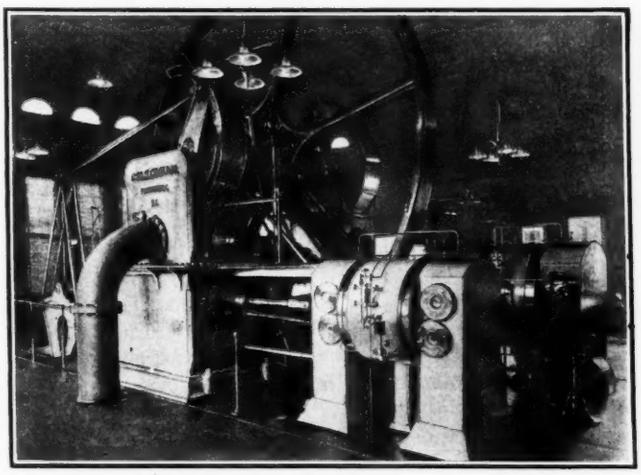


*Fig. 1—General view of Corliss pumping engine*

it over with black asphaltum. The engine has since been run with a vacuum instead of a steam jacket. Tests made on the vacuum jacket show it to be more efficient than the steam or air jacket.

However, I do not advise the indiscriminate use of the vacuum in the jackets as there is an element of danger. Heat will not radiate readily through a vacuum, and as the cylinder walls expand to conform to the temperature of the steam in the cylinder and the outer jacket is contracting to conform to the temperature of the room, you will realize that the length of the cylinder will be longer than the jacket. The old Corliss engine was so designed that the difference of expansion was taken care of.

This engine was regarded as George H. Corliss's masterpiece, as up to 1890 it was considered the most efficient steam engine.

The old Corliss boilers that supplied steam for this engine were taken out, and the engine was connected up

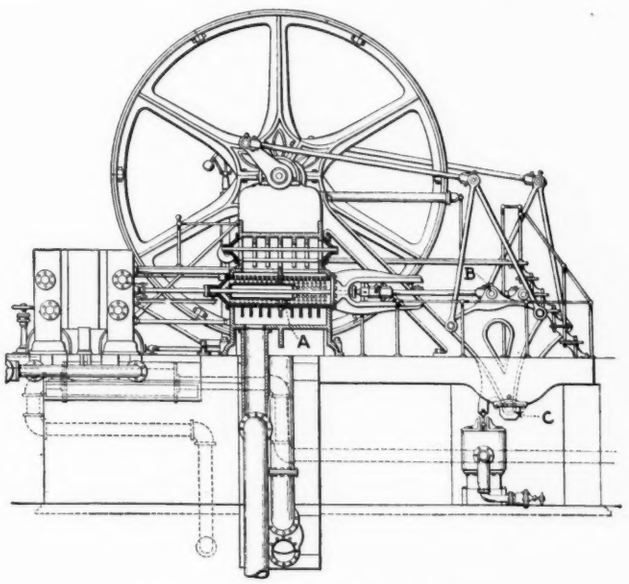



*Fig. 2—Sectional view of engine*

with the new boiler plant which supplies steam for the new 15,000,000-gal. triple-expansion pumping engine.

Referring to Figs. 1 and 2, the engine is cross-compound with piston rods connected directly to double-acting water-plungers *A*. The plunger rods are keyed to crossheads from which links run to vertical beams, the link connection being made in the center of the beam at *B* and the fulcrum at the lower end at *C*. From the upper end, connecting rods are coupled to cranks that are placed at right angles and have a throw equal to twice the stroke of the piston. The bearings for the crankshaft are carried on top of the pump air chambers, and braces run from these chambers to the main center pedestals of the beams.

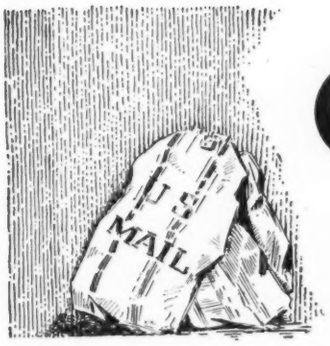
A jet condenser was employed with the engine, the injection water being supplied directly from the pump well.

The principal dimension of the engines, taken from "Pumping Machinery," by Barr, 1893, are:

| | |
|---|---|
| Diameter of high-pressure cylinder, in. | 15 |
| Diameter of low-pressure cylinder, in. | 30½ |
| Length of stroke, in. | 30 |
| Per cent cutoff high-pressure cylinder | 22 |
| Per cent cutoff low-pressure cylinder | 33.5 |
| Per cent clearance, high-pressure cylinder | 4 |
| Per cent clearance, low-pressure cylinder | 3.7 |
| Port area in percent of piston area: | |
| Admission high-pressure cylinder | 9.04 |
| Exhaust high-pressure cylinder | 14.8 |
| Admission low-pressure cylinder | 5.04 |
| Exhaust low-pressure cylinder | 9.08 |
| Diameter of pump plungers, in. | 10.52 |
| Diameter of all rods, in. | 2.75 |

The pump valves, of which there were 70 in each section of the pump, were of simple design; the disks were of sheet copper and were held to the valve seats by very light springs, the weight of the moving parts of each valve being approximately 8 oz. The pump operated at 52 revolutions a minute. W. H. ODELL.

Brooklyn, N. Y.




# QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

### Water Hammering from Feed Pump

*We have a battery of six 72-in. by 18-ft. h.r.t. boilers that are supplied from an open heater by a 10x6x10-in. duplex feed pump. There always has been banging and hammering in the feed lines, sometimes so bad as to jar loose internal feed pipes. The jarring occurs regardless of temperature of the water. How can the trouble be remedied?* *P. J. W*

Undoubtedly, the hammering occurs from the pump reversing its stroke in less time than required for the valves to become seated more gradually and quietly. No trouble should be experienced running the pump at about 24 r.p.m., giving 40 ft. of piston speed per minute, at which speed, if run continuously, its capacity should be sufficient, without hammering, for supplying six 72-in. by 18-ft. h.r.t. boilers at normal rating. The annoyance is likely to occur if the pump is used at higher speeds for feeding at intervals, especially if an air chamber is not provided on the discharge side and care is not taken to keep the air chamber from becoming filled with water.

### Coal Required To Heat Water

*In average commercial laundry practice, how much coal is consumed to heat 100,000 gal. of water from 50 deg. F. to 160 deg. F.?* *M. S.*

The water heating usually is performed by steam-heated coils or by discharging steam directly into the water. In usual laundry operation, where the steam is generated in boilers of 500 to 1,500 sq.ft. of heating surface, the average boiler economy, inclusive of fuel used for starting and banking fires, probably is equivalent to an average evaporation of about 5 lb. of water from and at 212 deg. F. per pound of coal, and under ordinary conditions about 5 per eent of the heat realized from the boiler is lost by radiation in transmission of the steam to the water, evaporation of the water and loss of heat from condensate intended to be returned as boiler-feed water. Assuming the evaporative economy to be equivalent to evaporation of 5 lb. of water from and at 212 deg. F. per pound of coal, the heat of steam generated per pound of coal would be $5 \times 970.4 = 4{,}852$ B.t.u. At the temperature of 50 deg. F., the weight of 1 gal. of water is 8.3432 lb., and the weight of 100,000 gal. would be 834,320 lb. To raise this quantity of water from the temperature of 50 deg. F. to 160 deg. F. would require $834{,}320 \times (160 - 50) = 91{,}775{,}200$ B.t.u., and since it is assumed that from each pound of coal there would be realized but $4{,}852 \times (1 - 0.05) = 4{,}609.4$ B.t.u., the coal required would be $91.775{,}200 \div 4{,}609.4 = 19{,}910$ lb., or 9.95 tons of 2,000 pounds.

### Piston Leakage

*How can piston leakage of a Corliss engine be determined?* *R. N. C.*

If the valves are tight, piston leakage is shown by removing the cylinder head of the engine and admitting steam to the crank end when the piston is in the head end of the cylinder. Standing behind the open cylinder, leakage of steam between the piston and cylinder walls is easily observed. In the same way the piston can be placed on dead center in the crank end or, by blocking the engine from turning, tests can be made for leakage from unequal wear of the cylinder at any point of the stroke. If it is not convenient to hold the engine from turning, fair tests can be made at different points by placing the piston a little nearer the crank end than the point where leakage is to be tested; then with the crank-end steam valve open the leakage may be observed by suddenly opening the throttle and closing it by the time the piston has passed over the part of the stroke to be tested. To make sure that the steam discharged from the open end of the cylinder is not leakage of the valves, make a test of the piston tightness with the steam and exhaust ports plugged with rod packing. If the packing is blown out before satisfactory observation can be made of piston leakage, to avoid interference from valve leakage it will be necessary to disconnect all but the crank-end admission valve and seal off the ports from the other valves at the valve seats.

### Free Air Taken in per Stroke of Compressor

*If an air compressor has a discharge pressure of 300 lb. gage, stroke 18 in., bore 12 in. and piston clearance $\frac{1}{8}$ in., how much free air is taken in for compression per stroke?* *W. W. P.*

When an air compressor is in operation, the volume of free air taken in during a suction stroke is the volume of air contained in the cylinder at the end of the suction stroke, reduced to atmospheric pressure and temperature, minus that part of the piston displacement that is occupied in the first part of a suction stroke by clearance air in the end of the cylinder at discharge pressure in the beginning of the stroke expanded down to atmospheric pressure and temperature.

If the effect of additional clearance volume due to counterboring and air passages is neglected, and it is assumed that the pressure at the intake through the suction stroke is atmospheric, or 15 lb. per square inch absolute, and all operations are performed with the same air temperature, then with $\frac{1}{8}$-in. piston clearance the compressed air at 300 lb. gage left in the clearance space would expand $(300 + 15) \div 15 = 21$ times its volume during the first part of the suction stroke,

before any fresh supply of atmospheric air could be taken into the cylinder. This would be when the piston was $21 \times \frac{1}{8} = 2\frac{5}{8}$ in. from the head end of the cylinder. As the piston would begin its stroke $\frac{1}{8}$ in. from the cylinder head, the length of stroke accomplished when the clearance air became expanded to atmospheric pressure would be $2\frac{5}{8} - \frac{1}{8} = 2\frac{1}{2}$ in. and free air at atmospheric pressure could be taken in during the balance of the suction stroke; that is, with $18 - 2\frac{1}{2} = 15\frac{1}{2}$ in. displacement of the piston. Assuming that at the beginning of the return or compression stroke the air pressure is atmospheric, the volume of free air taken in would be $(12 \times 12 \times 0.7854) \times 15\frac{1}{2} = 1{,}753$ cu.in., or $1{,}753 \div 1{,}728 = 1.01$ cu.ft. per stroke. In the crank end of the cylinder the volume of free air would be 1.01 cu.ft. divided by area of 12 in. diameter and multiplied by area of 12 in. diameter less the cross-sectional area of the piston rod.

## Coating for Steel Smoke Flue

*We are troubled with rusting away of our uncovered steel smoke flue between boilers and stack. What is the best kind of paint to use inside and outside?* *R. F.*

Before using paint or other coating inside or outside, the surfaces should be scraped and cleaned with a wire brush to remove dirt and soft iron rust. No paint should be used on the interior of the flue, as dust remaining in crevices is not likely to be thoroughly brushed into the paint and cavities may remain uncoated. After cleaning, the best protective covering for the interior is a wash of portland cement and water, mixed to a consistency of cold water paint and applied with a stiff brush. The outside of the flue should be painted with an asphaltic or a graphite paint, well filled into the joints to prevent rusting at the laps from infiltration of moisture from the atmosphere. The life of the flue will be greatly prolonged if it is protected from rain and snow.

## Priming of Boiler

*What are priming and foaming of a boiler and how are they prevented?* *W. L. G.*

A boiler is said to prime when water of the boiler is carried up and over with the steam as it is discharged from the boiler. Priming occurs when the water surface is so close to the steam outlet that particles of water projected upward in the steam space by ebullition of the water, or bubbles in the steam space due to foaming of the water, are swept along with the steam as it flows from the boiler. Remedies for priming due to ebullition are to have a larger disengaging surface of the water and deeper steam space in which the point of discharge is higher above the boiler water line. The activity of ebullition can be retarded temporarily by checking the fires or feeding more rapidly, but for a boiler already constructed the permanent remedy is to carry lower water level, or provide a dry pipe or other form of separator within the boiler, or take the steam from the top of a steam drum or separator placed above the old outlet.

Foaming is caused by any materials, either dissolved in the water or suspended in it, which retard or interfere with the free escape of steam from the water to the steam space. A collection of scum on the water surface is also a common cause of foaming. Such a scum may be caused by presence of oil, vegetable matter or sewage. If the water contains an alkali, any animal or vegetable oil that may find its way into the boiler is changed into soap, which forms suds and causes foaming. Similar foaming may also be caused by concentration of certain salts in the water, as from use of soda ash or other boiler compounds. Foaming that is productive of priming may be reduced, and in most cases can be prevented, by blowing down regularly and sufficiently; by cleaning the boilers regularly; by using feed water containing little or no oil, alkalies or vegetable matter; and by not forcing a boiler too much beyond its rated capacity.

## Boiler Pressure Relieved with Safety Valves in Tandem

*If the safety valve on a boiler is hooked up in tandem with another safety valve, so the discharge of the first valve is connected with the inlet of the second valve, and each valve is set to blow at 100 lb., at what boiler pressure would both valves open to release steam from the boiler?* *H. L. B.*

A safety valve is said to be "set to blow at 100 lb." when the valve will not open unless the pressure on the inlet side is at least 100 lb. more per square inch than the pressure against which the valve discharges. When each safety valve is "set to blow at 100 lb." and the valves are connected in tandem, the valve that discharges to the atmosphere would not open for less than 100 lb. per sq.in. gage pressure on its inlet side. But the discharge from the valve on the boiler could not build up pressure in the connection to the pop pressure of the outside valve before the inlet pressure of the valve next to the boiler became 100 lb. per sq.in. greater than the pressure in the connection. Therefore relief of steam by the outside valve would not take place until the boiler pressure became 200 lb. per sq.in. gage.

## Stopping Engine Off Center

*We have a 22 x 50-in. engine that is difficult to stop in a good position for starting, without some reversing and causing quarter-turn belts in the factory to run off their pulleys. For stopping the engine in good position for starting, could there not be a friction brake operated by a piston brought up with compressed air?* J. G. A.

For use on a factory engine that must be stopped only two or three times a day, a brake of suitable size and strength generally would be regarded as too cumbersome and expensive and would require quite as much skill for its operation as the usual provisions for making a good stop. Every engine is, or should be, provided with valve gear, starting bar, etc., for bringing it to rest in proper position for re-starting without having the engine reverse so much as to throw off quarter-turn driving belts. The knack of making a good stop usually requires exercise of skill and experience with the particular engine and shafting load. Overrunning and stopping on a dead center generally occurs from attempting to shut down to quickly, and a brake for checking the engine could hardly be expected to dispense entirely with the occasional use of a turning bar.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# Here and There in the Power Plant

## Load on Double-Sling Chains

By D. Fliegelman*

When a load is carried on a double sling chain, having an angle formed by its two branches, the tension in each branch is more than half of the total weight supported.

This is readily understood by one versed in mechanics and can be explained by the "parallelogram of forces" theorem or by the "resolution of forces" theorem, by one having a knowledge of trigonometry. To explain it without technicalities is somewhat more difficult. However, the following homely example, though not explaining the why's and wherefore's, will show that the condition does exist; namely, that the stress in each leg does increase as the angle between the two legs is increased.

Consider two men standing side by side and carrying between them a loaded traveling bag. This can represent a double sling chain (inverted if you will) with one arm of each person playing the part of one branch of the sling. As long as the two men stand close together with their arms down straight and parallel, the bag can be carried without much effort, or strain on the arms. It is assumed that the load is equally divided between the two. However, if the men stand two feet apart, thus forming an angle between their arms, the load seems heavier and the strain on the arms is much greater than before. And as they move still farther apart, thereby increasing the angle, the strain on the arms keeps increasing. Yet all the time the load supported—that is, the weight of the traveling bag—remains the same.

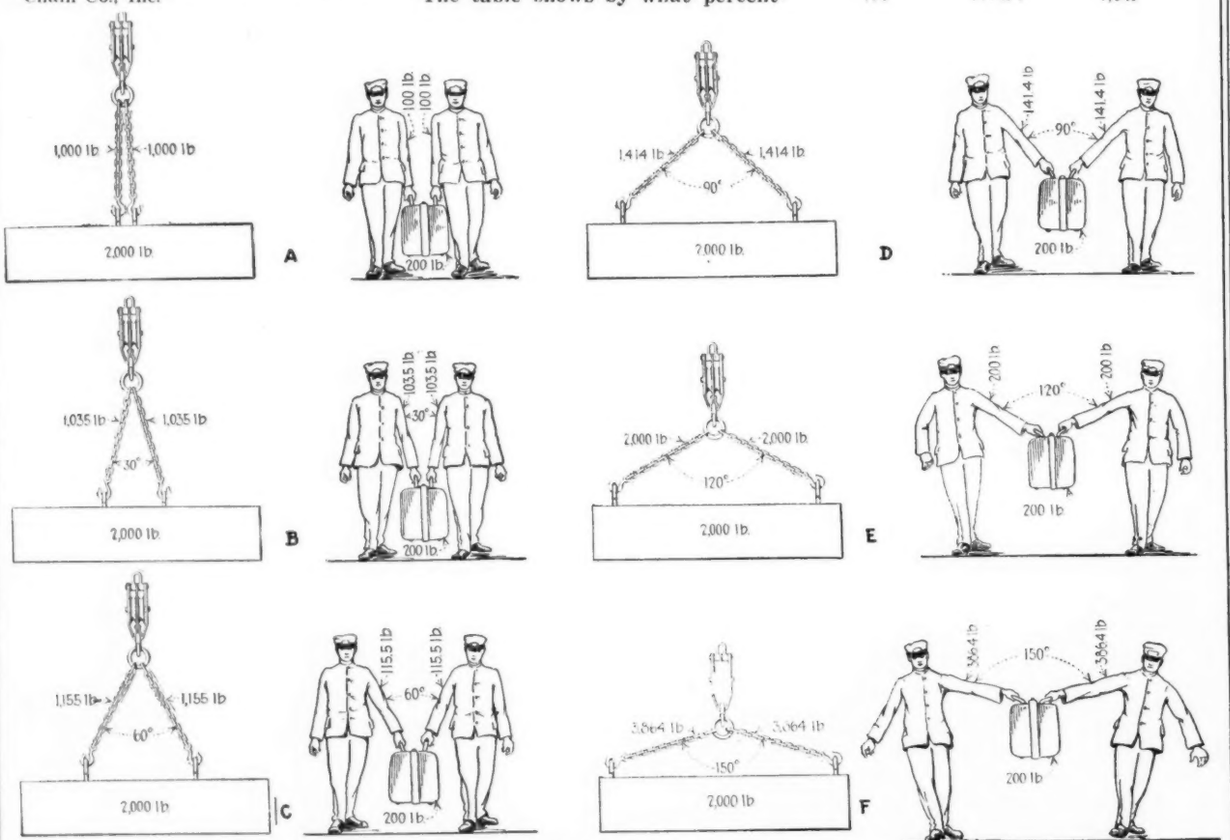
By taking an actual double sling chain and inserting a spring scale in each of the two branches and applying a load to the sling, the readings on the scales will prove the same principle. The sketches herewith show the analogy between the two arms supporting a load and a double sling chain and also show how the stress in each branch increases as the angle increases. The table shows by what percentage the tension in the branches increases for the various angles specified.

A great many chain failures are due to the slings being overloaded by users who are ignorant of the principle here illustrated. Although the chain may be sufficiently strong for the load when the legs hang straight, a much greater stress exists when the double sling is spread to a large angle. In fact, the stress may be so much larger than the safe working load that the chain may break.

HOW THE PULL INCREASES

| Angle Between Branches in Degrees | Ratio of Pull to That with Branches Vertical | Per Cent Increase of Pull over That with Branches Vertical |
|---|---|---|
| 10 | 1.004 | 0.4 |
| 20 | 1.015 | 1.5 |
| 30 | 1.035 | 3.5 |
| 40 | 1.064 | 6.4 |
| 50 | 1.103 | 10 |
| 60 | 1.155 | 15 |
| 70 | 1.221 | 22 |
| 80 | 1.305 | 30 |
| 90 | 1.414 | 41 |
| 100 | 1.556 | 56 |
| 110 | 1.743 | 74 |
| 120 | 2.000 | 100 |
| 130 | 2.366 | 137 |
| 140 | 2.924 | 192 |
| 150 | 3.864 | 286 |
| 160 | 5.759 | 476 |
| 170 | 11.474 | 1,047 |

*Chain Design Division, American Chain Co., Inc.




*A perfect analogy exists between the double-sling chain and the two men carrying a handbag*

When the supporting branches (chains or arms) are parallel, each carries half the weight. As the angle between them increases, the pull in each branch also increases. At first the increase is not important, but it becomes very great for the larger angles. At 120 deg., for instance, the pull in a single chain equals the total weight.

## Hot Water Incinerator Explosion

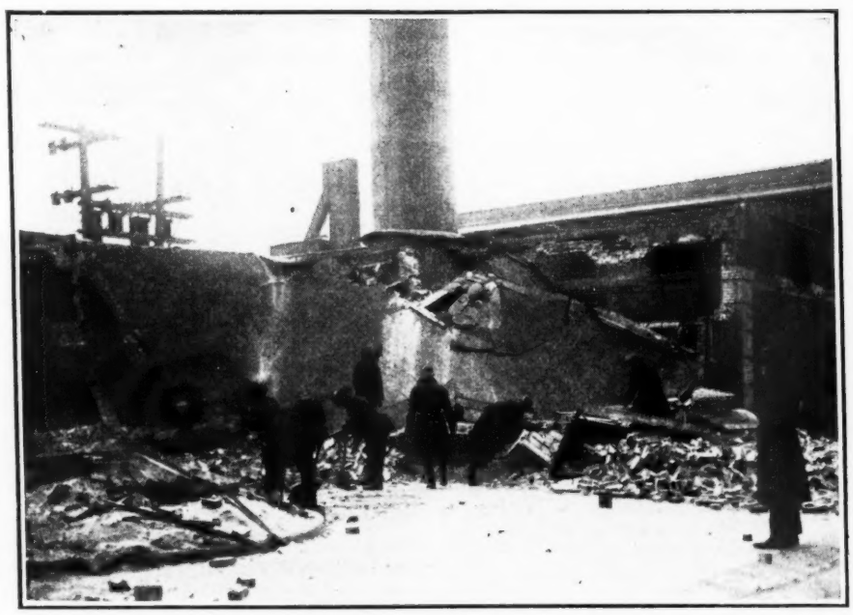
On Jan. 27 last the damage to the plant of the West Suburban Hospital at Oak Park, Ill., shown in the accompanying illustration, was caused by the explosion of a garbage incinerator. The explosion, occurring about 4 p.m., was violent and is said to have shook the hospital buildings, smashed windows, sent brick and hot coals into the hospital wards and completely demolished the incinerator building. The force of the explosion or the falling débris broke the return lines connecting the boilers to the hospital heating system and left the impression with those in that vicinity that a second explosion had occurred. It is fortunate no one was severely injured.

The incinerator was installed in 1922. It had the general appearance of similar vessels made by a number of manufacturers of boilers and pressure vessels. It was approximately 6 ft. long, 48 in. high and 42 in. wide, being formed of inner and outer steel sheets with a 3½-in. water space at the sides, end and crown. The sheets were supported by ⅞-in. staybolts spaced 8x8-in., and the base seam was welded. The incinerator and hot-water storage tank to which it was piped were subjected to city water-main pressure of about 50 lb. and were provided with a 1½-in. diameter water-relief valve set to operate at 60 lb. and with a thermometer to indicate the temperature of the heated water. The incinerator was in direct communication with the city water main at the time of the accident and the relief valve is said to have been in perfect working order, but was so badly damaged by the accident that it cannot be tested. However, it would appear that the pressure to which the vessel was subjected at the time of the accident was no greater than it was accustomed to carry.

The engineer reported visiting the incinerator room within four or five minutes preceding the accident, when he observed that the thermometer registered about 180 deg. F. and that the fire and other operating conditions were normal; although the violence of the explosion as indicated by the damage shown in the photograph would be considered as conclusive evidence that the vessel contained greater energy than would be stored in water at a temperature of 180 deg. F.

The initial rupture appears to have occurred in the autogenous welding securing the inner sheet to the outer sheet and extended the full length of the right-hand side of the base of the vessel. A considerable number of staybolts pulled from the inner sheet, permitting the sheets to separate and form an opening 37 in. wide through which the content of the incinerator was discharged downwardly against the foundation. The reaction caused the perpendicular flight of the incinerator and the upper part of the shell was dented 5 in. deep where it came in contact with a steel-reinforced concrete beam.

Few of those operating hot-water heating and storage apparatus consider an accident of this kind as within the range of possibilities, so the safety appliances customarily encountered in steam-boiler operation are often absent, although the majority of more recent installations are equipped with relief valves to safeguard the vessel against overpressure in case the valves in the inlet and outlet pipes are closed. A thermostat control to adjust automatically the damper or relieve the vessel of heated water in case the temperature exceeds the predetermined point (ordinarily about 180 deg.) is now recommended and forms a part of certain modern specifications. Both the relief valve and thermostat control appear to be of advantage with any installation of this kind and particularly where fusion welding has been used in uniting the plates forming either the hot-water heater or the hot-water storage tank.



*Damage at West Suburban Hospital from incinerator explosion*

## Coal the Wonder-Worker of Industry

Speaking upon the "Foundations of Industry" at the eighth annual banquet of the Providence (R. I.) Engineering Society, Feb. 5, Dr. George Otis Smith, Director of the United States Geological Survey, emphasized the enduring importance of bituminous coal in future power production and sketched the vital interest of the modern engineer in the economic production and use of this form of fuel. Part of his remarks were as follows:

"As we try to see future America in its place of pre-eminence among the nations of the world, we realize that our industrial supremacy will be permanent only as we fashion these abundant raw materials of ours into products that will meet the world's need—industry and commerce working together. And here is where our natural wealth holds out other promises on which we have only partly realized. Our supply of energy with which to strengthen the arm of human labor is larger than that of any other country. Of the developed water power in the world we have 41 per cent, and of the other two great sources of energy, coal and petroleum, our share is even larger. Through this wealth of natural resources our factories and our railways are equipped with power to an extent possible nowhere else in the world.

"Coal, water and oil are the slaves waiting to do our work with an even larger degree of economy and efficiency now than in the past. Of these energy servants, coal is the one on which industrial America must depend most; our potential water-power resources, great as they are, would prove insufficient to carry more than a small fraction of the power load east of the Mississippi River, and oil, with all its obvious economic advantages, must be recognized as the little sister of coal and pitifully short-lived. Last year was oil's boom year, yet the fuel-oil capacity of the American wells at the crest of their flood was only one-sixth or one-eighth the output of the bituminous coal mines. I realize that here in Rhode Island your public utilities carry all their increased load with fuel oil and that last year they burned so much more oil that their oil consumption has become a tenth of that used by all the public utilities in the country. Yet fuel oil cannot carry the load of the whole country and the increase in its use in power plants was far less than the increase in the use of coal.

"Butuminous coal is such a wonder-worker that it is cheap at any price. Think for a moment of the energy in a pound of coal as compared with its market price. Steam coal costs about a third of a cent a pound, so that under ordinary practice a cent's worth of coal will yield a horsepower-hour, the energy equivalent of a man day. Plainly, it pays to substitute coal for men, and herein lies America's opportunity to build a new industrial structure on the foundation of coal. When we compare this power equipment with the much smaller amount allowed the workers of other countries, a direct relation is seen between high power and high wages."

# Recent Publications

**Manual of Instruction for Welding Operators; Lessons, Exercises, Examinations.** Published by The Welding Engineer, 608 South Dearborn St., Chicago, Ill. Free.

This manual contains outlines for courses in oxyacetylene and electric-arcwelding where "The Welding Encyclopedia" is used as a text. The manual contains a temperature color chart and a flame chart in colors and other valuable material that should be of assistance to instructors, foremen, supervisors and students of welding.

**Natural Gas.** By Lester Clyde Lichty, Associate Professor Mechanical Engineering, University of Oklahoma. Published by John Wiley & Sons, Inc., New York City: Cloth; 6x9 in.; 516 pages; numerous illustrations and tables. Price, $7.50.

Engineering as applied to the handling of natural gas has been covered by the various technical schools in their courses only in the last few years. There has been a dearth of accurate data as to gas flow through pipe, etc., and this volume should find a ready acceptance by the engineering colleges and in addition by the practical man in the field.

**Standards for Electric Service.** Circular of Bureau of Standards No. 56, Second edition. Published by Government Printing Office, Washington, D. C., 1923. Paper; 7x10 in.; 344 pages; 17 tables. Price, 60 cents.

This circular presents a survey of the general field of state and municipal regulation in so far as standards of electric service are concerned, and suggests rules and regulations which may be adopted as proposed or which may form the basis for rules and ordinances to be adopted by states and cities. At present 31 states have adopted rules and recommendations for electric-service regulation. A survey of these regulations is given in this circular under such headings as, commission orders on electric service and safety, accidents, accuracy requirements for demand and watt-hour meters, deposits to insure payment of bills, discontinuing service, discount for prompt payment, frequency variation, grounding of transformer secondaries, meter-testing equipment, meter-testing methods and place, periodic tests of meters, referee or commission tests, voltage regulation, etc. In addition to a summary of the various state and municipal regulations the authors discuss the various requirements of a safe and adequate electric service. Although this circular is intended primarily for central-station companies and public-utility commissions, it contains much valuable information of power users as a basis on which to determine what is a safe and adequate electric service, and for this reason, it should find a wide field of usefulness among those interested in generation transmission, distribution and utilization of electric power.

**Rohrleitungen.** Machinen Bau-September, 1923. Verlag des Vereines Deutscher Ingenieure, Berlin, Germany. Sold by the American Engineering Standards Committee, 29 West 39th St., New York City. Paper; 9¼x12 in.; 48 pages. Price, 35 cents.

This reprint on pipe lines shows in considerable detail the plans of the German as well as the whole continental work in this field of standardization of iron and steel pipe, fianges and fittings. Piping for gases and liquids as a single entity, rather than as a group of unrelated problems, has been the continental tendency, a method making for considerable economy where practical. This standardization may have an important influence upon our foreign trade.

**Workings of Steam Boilers.** By Edward G. Hiller, Chief Engineer, National Boilers & General Insurance Co., Ltd., Manchester, England. Published by Bethell & Co., Ltd., Manchester, England. Paper or cloth; 148 pages; 88 illustrations. Price, paper 3/6 (80 cents), cloth 5/- ($1.25).

This little book contains a fund of information for those in charge of and responsible for the working of steam boilers. The directions and instructions given refer to matter which the experience of the author has shown to be essential to safety and also to various precautions necessary for satisfactory working and prevention of deterioration of steam boilers. Although the notes given apply directly to the type of land boilers used in Great Britain, the principles of care and management are applicable to other types. The subject of corrosion is particularly well treated, and many illustrations are presented showing how and where corrosion most frequently takes place.

**Testing** — A Monthly International Journal. A novel enterprise in the field of industrial journalism was initiated in January with the appearance of the first issue of *Testing*. It is described on the cover as "A monthly international journal devoted to the field of testing materials, structures and machinery." That this newcomer is truly international is at once made evident by a casual inspection of the contents. Of the twelve articles appearing in the first issue only five are written by Americans. Three articles come from England, two from Germany, one from Sweden and one from Austria. An even greater diversity of nationality exists in the list of thirty-four permanent collaborators. Of these only three live in America, although the magazine is edited and published in this country. Germany claims fifteen, Japan five, England four, and Austria three, while Scotland, Sweden, Italy and France are credited with one apiece.

The contents are of a solid but not over-mathematical nature and seem well adapted to the needs of specialists in the testing of materials. The subjects include alloy steels, wire ropes, notched-bar tests, research on duraluminum, calibration of testing machines, lubricating oils and bearing alloys, magnetic measurement for carbon in steel, a wood testing machine, etc.

This journal should do much to produce international co-ordination of work in the field of testing. The preponderance of German talent among the contributors will be largely offset by the advantage to English-speaking readers of having the magazine published in their own language. Under present conditions English is probably the most generally useful language for an international scientific publication. Before the war German would perhaps have been a more likely choice.

Except for a notice of one of the publisher's own books, *Testing* is entirely free from advertising. This doubtless explains the subscription rate of fifteen dollars, which at first sight seems very high for a monthly publication of small size. It may well be that the international character of the publication makes it impracticable to carry advertising since the readers—at least those in larger countries—might in any case buy most of their apparatus locally. *Power* wishes every success to this new venture, which will live in accordance with the dictum "Science should know no nationality."

**The Diesel Machine.** At the 1923 meeting of the Vereines Deutcher Ingenieure in Berlin last June a number of important papers on the development of the Diesel engine were read. Among them was an extensive one by Professor Nagel, in which he discussed the large M A N engines as well as the late solid-ignition Diesels. The V. D. I. has issued a book in which are reproduced the several papers. Those who are interested in oil-engine design will find a large amount of data in these papers. This volume may be procured from the Verein Deutcher Ingenieure, Berlin, Germany, the price being 5 gold marks.

**Size Standardization by Preferred Numbers.** By C. F. Hirshfeld and C. H. Berry. Reprint of paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City Dec. 4-7, 1923, as well as the discussion which accompanied the paper. Published and sold by the American Society of Mechanical Engineers at 29 West 39th St., New York City. Price 90 cents to members and $1 to non-members.

**Henley's 222 Radio Circuit Designs.** Published by the Norman W. Henley Publishing Co., 2 West 45th St., New York City. 256 pages. Price, $1.

**Mechanical World Year Book, 1924.** Published by Emmott & Co., Ltd., Mechanical World, 65 King St., London, England. Cloth; 6¼x4¼ in. Price, 50 cents.

**Standards of the Electric Power Club; Electric Power Apparatus.** Fifteenth edition, 1923. Published by the Electric Power Club, B. F. Keith Bldg., Cleveland, Ohio.

# News in the Field of Power

## Minority Views on Muscle Shoals Presented to Congress

### Nitrate Power Companies' and Ford Offers Compared

SIX members of the Committee on Military Affairs submitted on Feb. 9 to the House of Representatives a report, "Minority Views," signed by John M. Morin, Harry E. Hull, Harry C. Ransley, John Philip Hill, Louis A. Frothingham and J. Mayhew Wainwright. This report favors acceptance of the power companies' offer for Muscle Shoals.

Among other statements the report says that "the government has constructed works of tremendous importance at Muscle Shoals. They represent an investment of more than $135,000,000. This is the actual cost to the taxpayers of the United States.

Dam No. 2 and hydro-electric installation of 18 units will, when completed, be the largest dam in the world and represent an investment of more than $51,000,000. Nitrate plant No. 1 represents an investment of more than $12,000,000. A comparison of the main features of the two pending bills on Muscle Shoals is presented.

"The statement of the benefits Mr. Ford is to secure is not overdrawn. It presents few disputed points. No one denies that he demands that Congress ignore its own policy in regard to the use of the natural resource of flowing waters which are under Federal control. He must have this reversal of established governmental policy in respect to tenure of water-power rights—a grant of the people's heritage—for a term of 100 years, with preferential rights for a further period. . . ."

Mr. Wainwright added a note to the report as follows:

"Concurring in the conclusions of my colleagues that the Muscle Shoals properties should not be transferred to Mr. Henry Ford on the terms proposed, and that there are several other offers before the committee which offer greater advantages to the Government and the people, I have signed the foregoing minority report, but I entertain grave doubts as to the wisdom or expediency of in any event relinquishing the absolute control of this great natural resource of water power to any private interest upon any terms. Also I question whether Congress can ever arrive at a wise or satisfactory conclusion until the whole subject and all offers that have been or still can be adduced have been analyzed, considered, and reported on by a select commission as proposed by the President in his message at the opening of this session of Congress. J. MAYHEW WAINWRIGHT.

| HULL BILL (H. R. 6781), BASED ON NITRATE POWER COMPANIES' OFFER | M'KENZIE BILL (H. R. 518), BASED ON FORD OFFER |
|---|---|
| $15,000,000 of capital (one company). Owned by Americans. | $10,000,000 of capital (one company); personal liability of Ford limited to formation of corporation with above capital. Owned by Americans. |
| United States deeds to company: Nothing. | United States deeds to company property costing:<br>Nitrate plant No. 1 ..... $12,888,000<br>Nitrate plant No. 2 including 90,000 horsepower steam plant ..... 66,252,000<br>Waco quarry ..... 1,303,000<br>New 40,000 horsepower steam plant and transmission line to be erected by Government ..... 3,472,000<br>Total ..... $83,915,000<br>In addition to deeding above properties, United States also leases for 100 years the water-power plants, disregarding Federal water power act. |
| United States leases for 50 years nitrate plant No. 1 and power plants under Federal water power act. | |
| Agrees to make 50,000 tons annually of fixed nitrogen.<br>To furnish 100,000 horsepower for fertilizer at cost, and 40,000 additional as required.<br>To maintain nitrate plant No. 2 at present nitrogen capacity of 40,000 tons. | Agrees to make 40,000 tons annually of fixed nitrogen.<br>To maintain nitrate plant No. 2, or its equivalent (estimated by Ordnance Department to cost not over $100,000 per annum, or $10,000,000 in 100 years). |
| In case of war, 90,000 tons of nitrogen available. | In case of war, 40,000 tons of nitrogen available. |
| Government has right to recapture all property leased at end of 50 years. | No right of recapture as to nitrate plants, steam plants, and quarry.<br>Ford has preferred right to renew water-power leases at end of 100 years. |
| Offers cash payment of $4,500,000 for 90,000-hp. steam plant at Muscle Shoals if government desires to sell.<br>Government retains title to balance of properties. | Offers $1,527,512.75 for both nitrate plants, steam plants, and quarry costing government over $80,000,000 and divests government of title to same. |
| Rental Dams No. 2 and 3 for 50 years, $138,084,400; total for 100 years $295,624,400.<br>Savings to government for 50 years, $34,218,000. Savings to government for 100 years, $75,660,000. | Rental Dams No. 2 and 3 for 50 years, $103,866,654; total for 100 years, $219,964,954. |

## Civil Engineers To Discuss Power Subjects

The American Society of Civil Engineers, which is to hold its Spring meeting at Atlanta, Ga., from April 9 to 12 has scheduled its power division session for Thursday April 10. William P. Hammond, assistant chief engineer, Georgia Railway & Power Co., Atlanta, will speak on the "Operation of the Interconnected Power Systems of the South." This will be followed by a discussion. On Wednesday, April 9, Daniel W. Mead, professor of hydraulic and sanitary engineering, University of Wisconsin, will tell of the "Economics of Hydro-Electric Development." On April 11 and 12 inspection trips to power developments and plants of the Georgia Railway & Power Co. will be made.

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According to the district engineer of the United States Bureau of Geological Survey, Robert Follansbee, located at Denver, Colo., the state of Colorado during the "water year" utilized her water power for only 91,746 hp. (that is, all plants making over 100 hp.), yet if the proper effort had been made she could have obtained 2,560,000 hp. If the value of each annual horsepower is agreed to as worth $65, a conservative estimate, then Colorado has thrown away $160,436,510.

# Boulder Canyon Dam Project Favored by Hoover

## American Owners of Mexican Lands To Appear Before Committee

HEARINGS on the Colorado River Bill, now in progress before the House Committee on Arid Lands, took an unexpected turn on Feb. 13, when arguments by proponents of the bill were temporarily laid aside, and plans taken up to have appear before the committee, American citizens who are owners of Mexican lands, who might be affected, as well as representatives of power companies who would be interested in the proposed legislation.

This followed the presentation of the principal argument in favor of the bill, by its author, Representative Swing, of California, and the hearing by the committee of Secretary Hoover, chairman of the Colorado River Commission. Both these men presented arguments previously made by them at other hearings.

It had been planned to devote most of the time during the present hearings to the proponents of the bill, many of whom are in Washington from California and other Western States. The change in the Committee's plans came about as the result of accusations by Representative Swing that subterranean interests were in opposition to his bill. He charged that there is an offensive and defensive alliance between owners of Mexican lands and power interests, working by devious ways, to defeat his measure. Representative Baker demanded that Harry Chandler, owner of the *Los Angeles Times*, and alleged by Representative Swing to be a prominent member of the Mexican landholding group, be subpœnaed, and that executives of the power companies also be summoned to testify under oath.

### Engineering Opinion Divided

Dr. George L. Hoxie, a consulting engineer of the Southern California Edison Co., who was a spectator at the hearing, was asked if he had had instructions to try to defeat the Swing bill. He answered that he had not had any such instructions and stated that there were several plans for the development of the Colorado River that are more or less antagonistic to each other and that there is a division of engineering opinion on these subjects. Dr. Hoxie testified that a strong preference for a single plan is not to be interpreted as an endeavor to influence legislation by Congress respecting any other plan.

Members of the Committee desire to interrogate Mr. Chandler in regard to subjects relating to the proposed All-American canal, which is included in the Swing-Johnson bill. The committee decided that they did not have the authority to subpœna witnesses to testify under oath. There was some discussion about obtaining the necessary authority from the House, and Representative Leatherwood announced that if the necessary authority is not obtained, he will ask the House for authority to conduct an investigation.

Supporters of the project for Boulder Canyon Dam, were heartened by the official indorsement of the proposition by Herbert Hoover, Secretary of Commerce and chairman of the Colorado River Commission, who appeared before the House Committee on Irrigation of Arid Lands. In emphatic terms he declared that the situation in the Western States involved is one of "great urgency" and should be given immediate attention by Congress.

### Hoover Favors Boulder Dam

Boulder Canyon Dam, as provided for in the Swing-Johnson bill, is necessary, first from the viewpoint of flood protection, Secretary Hoover told the committee. He said:

"The dam would give immediate protection to the developments already made in the Imperial and Yuma valleys. This development of agricultural land is one for which we should have the greatest solicitude. The farmers are carrying on a day-to-day fight with the Colorado River. It has already broken over into the valley once, with destructive results. A second break of the river, which may come any day, would be more damaging than the first. Property bringing in $70,000,000, and the welfare and even personal safety of a population of 50,000 to 60,000 people are dependent upon the passage of this legislation in the near future. I think the matter is one of the utmost urgency."

Secretary Hoover told the committee that he considers construction of a dam and reservoir at the Boulder Canyon site much preferable to a site in the upper river, for "economic reasons." The Glen Canyon site, which is being urged by opponents of the Boulder Canyon project, is too far from the power market and would return little or no revenue from sale of electric power, according to Mr. Hoover.

Construction of the dam at Boulder Canyon will not preclude power development of the upper river later, he pointed out; any number of power dams above can be constructed without interfering with Boulder Canyon as a source of power and irrigation.

Approval of the Colorado River compact, which has been held up by refusal of Arizona to ratify, would remove much of the opposition of the states of the upper Colorado to the Swing-Johnson bill, Mr. Hoover told the committee. He explained that these states are fearful that they would be deprived of certain water rights if the Government constructs the reservoir at Boulder Canyon and that these rights are fully protected by the terms of the compact.

These states hold, he explained, that the storage of water in the reservoir would be considered as "beneficial use" and that the water as such would be subject to the right of prior appropriation by the federal government. Ratification of the Colorado compact by Arizona would remove all such objection through its provisions specifically allocating water rights to the states of the upper and lower basins.

## Technical Bureaus Not To Be Transferred at Present

In the opinion of Secretary of Commerce, Mr. Hoover, no executive order transferring the Bureau of Mines or other technical bureau, to his department will be issued pending the report of the joint committee on reorganization. The committee is awaiting the printing of the hearings before attempting to discuss recommendations. Senator Harrison, one of the members of the committee, expresses the opinion that a portion of the program outlined by Walter Brown, the chairman of the committee, will be recommended.

## Celebrate Steel Point Opening

On the evening of Feb. 11 nearly two hundred engineers and business men gathered at a Bridgeport (Conn.) shore house for a banquet and general jollification. The occasion was the completion of the first 30,000-kw. section of the United Illuminating Company's Steel Point Station (described in the Feb. 12 issue). The staffs of Westcott & Mapes (the designers) Casey & Hurley (the contractors) and the United Illuminating Co. were well represented, as were the manufacturers of the equipment used.

Work has been started on an extension that will double the present capacity of the Steel Point Station.

## Diesel Engines Approved by Committee

By adopting unanimously a report recommending passage of his bill providing for use of Diesel engines in American ships, Representative Edmunds, of Philadelphia, believes the House Merchant Marine and Fisheries Committee has pointed the way for a tremendous development of a modern American merchant fleet.

The bill authorizes the United States Shipping Board to use $25,000,000 of its present construction fund for converting government-owned vessels from the ordinary type of steam-engine driven craft into ships propelled by the Diesel-type engines.

Practical demonstration, according to Mr. Edmunds, who is ranking majority member of the Merchant Marine and Fisheries Committee, has demonstrated that ships equipped with Diesel engines can be operated at 40 per cent less cost than other ships, by reason of their lower fuel consumption, their greater efficiency and the increased cargo capacity due to the removal of steam boilers and the reduction of fuel space.

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The *Power* Index for July to December, 1923, inclusive, is now ready and as usual will be mailed to any subscriber upon request.

## Progress Reported on Mohawk River Power Plants

Royal K. Fuller, State Commissioner of Canals, in an interview recently stated that the work of constructing the two power buildings at Crescent Dam and Vischer Ferry on the canalized Mohawk River is progressing and that the generating machinery will be installed in the spring and summer, but that he did not expect either of the plants would be ready to produce power before the spring of 1925.

The state proposes to generate electric power at these two dams under a law passed in 1922, for sale to private companies. The estimated cost of Crescent Dam project, when the law was passed in 1922, was $1,064,965 and of the one at Vischer Ferry $1,119,415. These totals, it is said, will be exceeded by perhaps $500,000 before the work has been completed.

## Output of Electricity in 1923 Greatest for Five Years

The total production of electricity by public-utility power plants for 1923 was 55,928,000,000 kw.-hr., an increase of more than 17 per cent over the output for 1922. The output in kilowatt-hours for each of the past five years and the percentage produced by water power were as follows:

| Year | Kw.-Hr. | Per Cent |
|---|---|---|
| 1919 | 38,921,000,000 | 37.5 |
| 1920 | 43,555,000,000 | 37.1 |
| 1921 | 40,976,000,000 | 36.5 |
| 1922 | 47,659,000,000 | 36.1 |
| 1923 | 55,928,000,000 | 35.1 |

These figures indicate that water power apparently is not holding its own, as the percentage has decreased from 37.5 in 1919 to 35.1 in 1923. The production of electricity by the use of water power, however, is dependent upon the amount of water available for use of water-power plants and serious droughts have occurred in the last two years in different sections of the country, which have materially affected the flow of the streams in those sections.

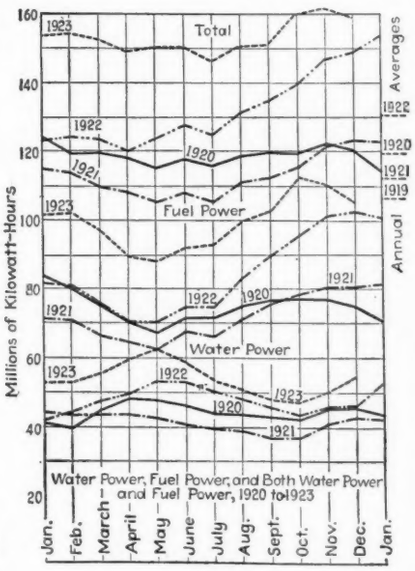
The amount of electricity produced by the use of water power in 1923 at public-utility power plants would have required the consumption of about 23,500,000 tons of coal. This is equivalent to nearly 1,300 carloads a day.

There was a small increase in the efficiency in utilization of fuel during 1923 as compared with 1922, as the average rate of consumption of coal in 1923 was about 2.4 lb. per kw.-hr. as compared with 2.5 lb. in 1922. Even this small gain is equivalent to 1,800,000 tons of coal during the year.

The average daily production of electricity in kilowatt-hours and the percentage produced by water power for each month in 1923 were as follows:

| Month | Kw.-Hr. | Per Cent |
|---|---|---|
| January | 153,300,000 | 34.0 |
| February | 154,400,000 | 33.9 |
| March | 152,500,000 | 36.3 |
| April | 149,100,000 | 39.9 |
| May | 150,100,000 | 41.3 |
| June | 150,800,000 | 38.9 |
| July | 146,300,000 | 36.4 |
| August | 150,600,000 | 33.6 |
| September | 151,200,000 | 32.3 |
| October | 159,700,000 | 29.7 |
| November | 161,100,000 | 31.0 |
| December | 159,600,000 | 34.1 |

The quantities in the tables are based on returns received from 3,500 power plants. The output for those plants that do not report is estimated. Prepared under the direction of A. H. Horton in the U. S. Geological Survey.




*Power curve rises in 1923*

CONSUMPTION OF COAL AND ITS EQUIVALENT* IN OTHER FUELS

| Year | Net Tons | Pounds per Kw.-Hr |
|---|---|---|
| 1919 | 38,880,000 | 3.2 |
| 1920 | 41,420,000 | 3.0 |
| 1921 | 35,240,000 | 2.7 |
| 1922 | 38,000,000 | 2.5 |
| 1923 | 43,365,000 | 2.4 |

* One ton coal = 4 bbl. oil = 35,000 cu.ft. of gas (approximately).

Note: 1923 figures are preliminary and are subject to revision.

## Water-Power Projects

**Uruguay to Have New Hydro-Electric Plant.**—According to *Commerce Reports*, negotiations for a contract between the Uruguayan government and an American company for the construction of a $15,000,000 hydro-electric plant are reaching their final stages, and it is expected that construction work on the project will begin during the early part of 1924.

**Welsh Water Power Project Started**—Work is reported to have commenced on a water-power development scheme in North Wales, 500 men being employed, with the expectation of increasing this number when the plans and surveys have been completed. The project is being undertaken by the North Wales Power & Traction Co. under the trade facilities act. It involves the construction of 600 miles of transmission lines carrying electric current over the whole of North Wales and part of Cheshire, according to *Commerce Reports*.

**Hydro-Electric Power Plant to Be Built in Alberta.**—A hydro-electric project involving a probable expenditure of $7,000,000 is under way by the provincial government of Alberta, Canada. Application has been made to the Dominion Government for the priority right to survey and develop a power site in the Banff National Park, about 90 miles west of Calgary, at what is generally known as the Spray Lakes power site. The construction will include storage dams, storage reservoir, flumes, tunnels, penstocks, and a power plant. It is stated that over 100,000 hp. may be developed from the Spray Lakes project alone. Action on the applications will be taken by the Dominion Government during the first part of this year, according to Commerce Reports.

**Quebec developments**—Construction of a number of water-power projects are in active prospect in different parts of Quebec province. These include a 15,000-hp. plant on the Batiscan River, a plant of 80,000 hp. at Lachine Rapid on the St. Lawrence River, a 50,000-hp. development on the des Prairies or Back River, two projects on the Gatineau River—the first at Chelsea of 100,000 hp. and the other at Paugan Falls of 60,000 to 100,000 hp.—a development on the Megiskan River in northern Quebec of 10,000 to 20,000 hp. in connection with a pulp and paper mill, and a 21,000-hp. plant on du Loup River, Maskinonge County, near St. Paulin.

**Flathead River, Montana.** To determine the potential power and storage available on the South Fork of the Flathead River, Montana, an engineer of the Geological Survey was detailed to make a reconnaissance to ascertain whether or not a feasible site for a dam could be found along the lower reaches of the river. A site was found where a dam 350 ft. high would create a reservoir having a capacity of 1,320,000 acre-feet. A mean effective head of 280 ft. could be obtained at the reservoir, which would make potentially available more than 90,000 hp. A manuscript report has been prepared which describes the dam site and presents the technical details upon which the conclusions are based. In order that the data on the potential power of streams examined by the Geological Survey may be of greatest use to those interested, a copy of this report will be sent on request to the office of the district engineer nearest the applicant, where it can be consulted.

**Hydro-electric Industries Increasing In Italy.**—According to the report of the General Confederation of Italian Industries, Engineer Civita, at a meeting of the Italian Electro-technical Association gave the following interesting data regarding the situation of the hydro-electric industries in Italy. In 1915 the power generated by the central stations amounted to 1,520,000 hp.; in 1922 the figure was 2,170,000 hp., or an increase of 55 per cent. The increase during 1921-22 amounted to 300,000 hp., while 67 new plants were opened during those years, of which 15 are provided with reservoirs and artificial lakes, impounding 78,375,000 cubic meters of water. Important works will shortly be taken up in the

Trentino, Venezia, which in three or four years will bring the power harnessed to industry up to 3,000,000 hp.

The capital invested in this industry is constantly increasing. In 1915, 700,000,000 lire was invested in these plants, and on Dec. 31, 1922, the amount had increased to 2,070,000,000 lire; and if the sums invested in municipal and small privately owned plants are considered, the total is 2,650,000,000 lire. The investment will, it is believed, amount to 3,000,000,000 lire by the end of 1923, and in three or four years it will exceed 5,000,000,000 lire.

As a consequence of the depreciation of the lire, the cost of the plants per unit of power generated has risen from 500 lire in 1915 to about 3,000 lire in 1921-22.

## Society Affairs

**The Metropolitan Section of the A.S.M.E.**, will hear W. S. Murray on "The Real Meaning of Superpower and its Relation to Railway Electrification," at its Feb. 27 meeting.

**The Los Angeles Section of the A.S.M.E.** will hear C. V. Kerr, of the Kerr Turbine Co., speak on the subject of "Pumps" at its Feb. 28 meeting at the City Club.

**Southern Sections of the A.S.M.E.** will hear Fred R. Low, president of the A.S.M.E. speak to them on the following dates: Savannah, March 3; Raleigh Branch, March 4; Virginia Section, March 5.

**The World Power Conference** to be held in London from June 30 to July 12 will hear a paper by Barton R. Shover, past president of the Association of Iron and Steel Electrical Engineers, "Power in the Steel Industry," at one of its sessions next summer.

**The Chicago Section of the A.S.M.E.** will on Feb. 27, at a dinner meeting at the City Club, hear Calvin W. Rice speak on "The Engineer's Contribution to the Community," and Mayor Dever will also speak on the possible future growth of Chicago and the part the engineer will play in this development.

**The Minneapolis Section of the A.S.M.E.** jointly with the **St. Paul Section A.S.M.E.** and **Student Branch of the A.I.E.E., Minnesota Section of the A. S. H. & V. E.** and the **Minnesota Section of the American Chemical Society** will hold an all-day session on Feb. 28 at the University of Minnesota, Minneapolis. In the afternoon there will be an inspection of the University laboratories and shops, Max Toltz, of Toltz, Kind & Day, will speak on "Powdered Fuel," and Dr. C. S. Mann, of the University of Minnesota, will have as his subject, "Colloidal Fuel." Dinner will be at the Men's Union. The evening subjects will be: "Minnesota Peat," Prof. G. B. Christianson of the University of Minnesota; "North Dakota Lignite," by Prof. G. B. Wharen, University of North Dakota; "Low-Temperature Distillation of Coal," by Dr. Hans Holzwarth, of Thyssen & Co., Germany.

## Coming Conventions

**American Electrochemical Society.** C. G. Fink, Columbia University, New York City. Meeting at Hotel-Bellevue-Stratford, Philadelphia, Pa., April 24-26.

**American Institute of Electrical Engineers.** F. L. Hutchinson, 29 West 39th St., New York City. Spring convention at Birmingham, Ala., April 7-10.

**American Society of Civil Engineers.** John H. Dunlap, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., April 9-12.

**American Society of Mechanical Engineers,** Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Cleveland, Ohio, May 26-29, formerly announced, May 19-22.

**American Water Works Association.** J. M. Diven, 153 West 71st St., New York City. Annual convention at New York City, May 19-21.

**Association of Iron and Steel Electrical Engineers.** W. M. Chandler, 708 Empire Building, Pittsburgh, Pa. Fuel Saving Conference—Combustion Engineers. April 2-3.

**Electric Power Club.** S. N. Clarkson, Keith Bldg., Cleveland, Ohio. Meeting at Seaview Golf Club, Absecon, N. J., May 26-29.

**Indiana Engineering Society.** Charles Brossman, 1503 Merchants Bank Bldg., Indianapolis, Ind. Annual meeting at Lincoln Hotel, Indianapolis, Ind. Feb. 14-15.

**International Railway Fuel Association.** J. B. Hutchinson, 6000 Michigan Ave., Chicago. Annual convention at Hotel Sherman, Chicago, Ill., May 26-29.

**Master Boiler Makers Association.** H. D. Vought, 26 Cortlandt St., New York City. Meeting at Chicago, May 20-23, 1924.

**National Association of Stationary Engineers.** Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **Kansas Association** at Parsons, Kans., April 16-18. J. M. VanSant, 739 Horne St., Topeka, Kan. **Indiana Association** at La Fayette, Ind., May 5-6. Prof. A. W. Cole, Purdue University, Lafayette, Ind. **New Jersey Association** at Newark, June 6-8. Joseph P. Flynn, 612 Franklin St., Elizabeth, N. J. **Iowa Association** at Sioux City, June 10-14. Abner Davis, 16 Waterhouse Block, Cedar Rapids, Iowa. **Ohio Association** at Akron, June 19-21. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at Bridgeport, Conn., June 27-28. George F. Klopfer, 30 East Pearl St., New Haven, Conn. **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Minnesota Association** at Fairbault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22 Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids.

**National District Heating Association,** D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 11-14, 1924.

**National Electric Light Association.** M. H. Aylesworth, 29 West 39th St. New York City. Annual convention at Atlantic City, Young's Million-Dollar Pier, May 19-24.

**Society of Industrial Engineers.** George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

**World Power Conference.** O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

**The Vancouver (Wash.) Section of the A.I.E.E.** has as the topic for its March 7 meeting "Automatic Substation Operation and Some Features of Power Factor Correction." R. L. Hall is to be the speaker.

**The Washington Section of the A.S.M.E.** will hold a meeting at the Cosmos Club on Feb. 29. L. W. Wallace, secretary of the American Engineering Council, will speak on "The Engineer's Participation in Public Affairs."

**The Engineers' Society of Milwaukee** will devote the meeting to be held on Feb. 27 to a discussion on "Co-operation Between the University of Wisconsin and the State Industries." The speakers will be G. L. Larson, professor of steam and gas engineering at the University of Wisconsin, Robert N. McMynn and Milton C. Potter.

## Personal Mention

**O. P. Conrad,** of Logansport, Ind., has been appointed master mechanic for the Munro Iron River Mining Co. at Iron River, Mich.

**Harry A. Brinkerhoff,** formerly of the firm of Stovel & Brinkerhoff, of New York City, has been elected city manager of Portland, Maine.

**P. Albert Poppenhusen,** of Chicago, a former president of the Green Engineering Corp., is planning for a trip around the world. He expects to sail on Feb. 21 and return about Oct. 1.

**Robert N. Barclay,** formerly electrical engineer with Starrett & Van Vleck, New York City, has become associated with Stone & Webster, Inc., Boston, Mass., as engineer in the electrical division.

**Theodore Maynz, M. E.,** 3326 Kenmore Road, Shaker Heights, Cleveland, Ohio, has severed his connection with the Cleveland Electric Illuminating Co. and is now prepared to give consulting service on the utilization of fuel and the generation and application of steam and electric power in all its phases.

## Business Notes

**The Sullivan Machinery Co.,** Chicago, Ill., announces the change of its Birmingham, Ala., office from the Brown Marx Bldg., to 2108 Fifth Ave. N.

**Warren Webster & Co.,** manufacturers of steam heating systems, feed water heaters and steam specialties have moved into their new plant at Federal and Seventeenth Sts., Camden, N. J. The move was made necessary by the fact that the former plant was on the site taken for the new Camden-Philadelphia bridge.

**The Heine Boiler Co.,** St. Louis, Mo., is announcing a change in its sales organization for the State of Texas. The Tennant Co., Union National Bank Bldg., Houston, will be its representatives for the southern half of the state; Smith & Whitney, of Dallas, will continue as representatives for the northern half.

## Trade Catalogs

**Grinders.** Hisey-Wolf Machine Co., Cincinnati, Ohio. Leaflet describing wide-swing floor-stand motor-driven grinder.

**Equipment, Electrical.** Fuerst-Friedman Co., Cleveland. Series of cards illustrating and describing the equipment which can be obtained from this company.

**Pipe & Fittings, Steel.** Steere Engineering Co., Detroit, Mich. Leaflet showing steel pipe and fittings for any medium- and low-pressure work; gas, water, steam and air.

**Water Softener.** H. S. B. W.-Cochrane Corp., 17th St., below Allegheny Ave., Philadelphia, Pa. Pamphlet, "The Treatment of Boiler Feed Water for Highly Overloaded Boilers," by David Henderson, gives the chemistry and advantages of the Cochrane method of treating boiler feed water.

**Instruments, Switchboard** — Roller-Smith Co., 233 Broadway, New York City. Bulletin No. 400 describes small, direct-current switchboard instruments; ammeters, milli-ammeters, voltmeters, milli-voltmeters, volt-ammeters but does not include the PV type.

## Fuel Prices

### BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

| Coal | Market Quoting | Feb. 4, 1924 | Feb. 11, 1924 |
|---|---|---|---|
| Pool 1 | New York... | $3.25 | $3.25 |
| Smokeless | Columbus.... | 2.25 | 2.25 |
| Clearfield | Boston | 2.50 | 2.40 |
| Somerset | Boston | 2.50 | 2.50 |
| Kanawha | Columbus.... | 1.75 | 1.75 |
| Hocking | Columbus.... | 2.00 | 2.00 |
| Pittsburgh No. 8 | Cleveland... | 2.10 | 1.85 |
| Franklin, Ill | Chicago | 2.50 | 2.50 |
| Central, Ill | Chicago | 2.25 | 2.25 |
| Ind. 4th Vein | Chicago | 2.75 | 2.75 |
| West Ky. | Louisville... | 1.90 | 1.90 |
| S. E. Ky. | Louisville... | 2.00 | 2.00 |
| Big Seam | Birmingham | 1 85 | 1.85 |

### FUEL OIL

**New York**—Feb. 14, light oil, tank-car lots, 28@34 deg Baumé, 5c. per gal., 36@40 deg. 5¼c. per gal., f.o.b. Bayonne, N. J.

**St. Louis**—Feb. 5, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95@$2 per bbl.; 26@28 deg., $2@$2.05; 28@30 deg., $2.05@$2.10; 32@36 deg., gas oil, 5¼@5¾c. per gal.; 36@40 deg., distillate, 6¼@6½c. per gal.

**Pittsburgh**—Feb. 8, f.o.b. local refinery, 30@34 deg., fuel oil, 5½c. per gal.; 36@40 deg., fuel oil, 6c.; 34 deg., neutral 9¾c. per gal.

**Dallas**—Feb. 8, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

**Cincinnati**—Feb. 11, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 6c. per gal.; 30@32 deg., 6½c.; 38@42 deg., distillate, 7½c. per gal.

**Philadelphia**—Feb. 8, 28@30 deg., $2.31@$2.36 per bbl.; 18@22 deg., $2.10 @$2.16½; 13@16 deg., $1.45@$1.51½ per bbl.

**Boston**—Feb. 5, tank-car lots, f.o.b. heavy oil, 12@14 deg Baumé, 4⅝c. per gal., light oil, 28@32 deg. Baumé, 6⅝c. per gal.

**Chicago**—Feb. 9, 24@26 deg., $2.12 per bbl.; gas oil, 32@36 deg., 4.93c. per gal.

# New Plant Construction

**Ark., Altheimer**—The Board of Public Improvement has tentative plans for the installation of electric-operated pumping equipment in connection with proposed extensions in the waterworks.

**Ala., Florence**—The United States Engineer Office will take bids until March 4, for two motor-generator sets, one rotary converter, switchboard and other equipment for the Wilson dam power house, as specified in Circular 24,349.

**Ala., River Falls**—The River Falls Power Co. has plans under way for the construction of a hydro-electric power plant on the Conecuh River with initial capacity of 7,500 hp. The Southern Engineering Corp., Albany, Ga., is engineer.

**Alaska, Anchorage**—The city clerk and other municipal officials, F. I. Reed and associates, are interested in a project to construct and operate a hydro-electric power plant on the Ekultna River for municipal service. A fund of $100,000 has been raised and additional appropriations will be secured. The plant is estimated to cost $400,000.

**Ark., Ozark**—W. A. Sossman plans for the construction of a steam power plant in connection with a new local cotton ginning plant, estimated to cost $50,000.

**Ark., Searcy**—The Searcy Cotton Compress Co. is reported to be considering the construction of a power house in connection with the rebuilding of its local plant, recently destroyed by fire with loss of $375,000, including equipment.

**Calif., Auburn**—Fred P. Tuttle, Jr. and associates have secured permission from the state water department to use waters from the North and Middle Forks of the American and Rubicon Rivers for proposed hydro-electric development. The plant capacity is estimated at 107,000 hp., and the project calculated to involve $18,000,000.

**Calif., Fullerton**—The Western Glass Co. plans for the construction of a power house at its proposed local plant, estimated to cost $300,000. W. D. French is superintendent of construction, in charge.

**Calif., Livermore** — The United States Veterans' Bureau, Room 791 Arlington Building, Washington, D. C., will receive bids until March 28, for a raw-water ice-making and complete refrigerating plant for installation at the local Veterans' Hospital, as per plans and specifications on file. Frank T. Hines is director; William H. Radcliffe is bureau representative at the hospital, Livermore.

**Calif., Los Angeles**—The Public Service Commissioners have secured permission from the state water department to use waters from Rock Creek and East Fork Rock Creek for hydro-electric development for the city, with total estimated capacity of 12,300 hp., to cost approximately $1,700,000.

**Calif., Monte Vista**—The West Ontario Citrus Association, Ontario, Russell K. Pitzer, president, is considering tentative plans for the installation of a cold storage and refrigerating plant at its proposed local packing house, estimated to cost $200,000.

**Calif., Oroville** — The Feather River Power Co., affiliated with the Yuba River Power Co., has plans under way for the construction of two hydro-electric generating plants in the vicinity of Grizzily Creek and Gold Lake, Butte County, each with capacity of 30,000 hp., to cost in excess of $4,000,000. Lars Jorgensen, Hobart Building, San Francisco, is engineer in charge.

**Calif., Riverside**—The Cain Irrigation Co., is reported to be planning for the construction of an electric-operated pumping plant in connection with additional water supply for irrigation service from Mill Creek, estimated to cost $100,000.

**Calif., Smartville**—The Excelsior Water & Power Co. is planning for the construction of an electric-operated pumping plant in connection with additional water supply from the South Yuba River for irrigation service, estimated to cost $125,000.

**Conn., New Haven**—The General Baking Co., 342 Madison Avenue, New York, plans for the installation of a steam power plant, ovens, conveying machinery and auxiliary equipment at its proposed local baking plant, for which preliminary plans are being prepared by Francisco & Jacobus, 511 Fifth Avenue, New York, engineers.

**Conn., Waterbury** — The Connecticut Light & Power Co. plans for extensions in its power plants to increase the output by about 90,000 hp. during the present year.

**Fla., Quincy**—Allen & Cory, Inc. is having plans prepared for the construction of an ice-manufacturing plant, using hydraulic power for operation. The Southern Engineering Corp., Albany, Ga., is engineer.

**Ill., Charlestown**—C. H. Miller, director of Public Works and Buildings, Capitol Building, Springfield, Ill., is asking bids for the construction of a power house at the local state normal school, to cost approximately $100,000. Edgar A. Martin, 304 South Wabash Avenue, Chicago, is engineer.

**Ill., Galva**—A. W. Johnson, city clerk, will receive bids until March 4, for one 125 and one 40 kva. crude oil driven generators; two 500 g.p.m. centrifugal pumps; and one 375 cu.ft. free air, compound air compressor, motor-drive. The J. D. Rankin Co., Chicago, is consulting engineer.

**Ill., Rockford**—The Chicago Grain Products Co., 1602 South Main Street, plans for the construction of a boiler plant at its proposed local distillery, estimated to cost $100,000, for which bids will soon be asked. Charles W. Bradley & Sons, Brown Building, are architects.

**Ind., Hammond** — The Western Grain Products Mfg. Co. is said to be considering the construction of a boiler plant in connection with the proposed rebuilding of its local mill, recently destroyed by fire with loss of about $150,000.

**Ind., Jasper**—The Jasper Wood Products Co., recently organized, plans for the construction of a boiler plant at its proposed local mill, estimated to cost $70,000. Clarence U. Gramelspacher and Andrew W. Berger, Jasper, head the company.

**Iowa, Fort Dodge** — The Northwestern Mfg. Co. plans for the immediate erection of a new power plant, estimated to cost in excess of $75,000.

**Ky., Henderson**—The Kentucky Box & Crate Co., recently incorporated, is reported to be planning for the construction of a boiler plant at its proposed local three-story mill. T. B. Stevenson is one of the heads of the company.

**La., New Orleans**—The Hospital Board of the Southern Baptist Convention, Dr. F. S. Groner, chairman, building committee, Dallas, Tex., plans for the construction of a steam power house at the proposed local hospital unit to be erected on Napoleon Avenue, near Claiborne Street, estimated to cost $500,000. Favrot & Lavaudais, New Orleans, are architects.

**Mich., Jackson**—The Consumers Power Co. has arranged a fund of $15,000,000, for extensions and improvements in plants and system during the present year, to include the construction of an additional unit at the Battle Creek power plant; completion of steam-operated generating plant on the Saginaw River with total capacity of 60,000 hp.; and completion of hydro-electric power plant on the AuSable River.

**Minn., Redby** — The Minnesota State Game and Fish Commission, Old Capital Building, St. Paul, will commence the

construction of a cold storage plant on local site. Charles Berger, Phoenix Building, Minneapolis, is architect.

**Minn., St. Cloud**—The St. Cloud Public Service Co. plans for the immediate rebuilding of the portion of its local generating plant, destroyed by fire, Feb. 6, as the result of an explosion, with loss reported at close to $90,000, including equipment.

**Minn., St. Paul**—The Ford Motor Co., Highland Park, Detroit, Mich., will build an auxiliary steam-operated power plant in connection with its hydro-electric generating station on the Mississippi River, near High Dam, on which work has been commenced. It will cost in excess of $500,000.

**Minn., Winsted**—Citizens have failed to approve a bond issue of $50,000 for a waterworks, with proposed electric-operated pumping station and the Council will temporarily abandon the project. John W. Shaffer & Co., New York Life Building, Minneapolis, Minn., are engineers.

**Miss., Brooksville**—G. T. Heard is in the market for an ice-making machine, about 4-ton capacity, for installation in a local plant, with auxiliary equipment.

**Neb., Hay Springs**—The Common Council contemplates the installation of electric-operated pumping equipment at the proposed municipal waterworks.

**Neb., Primrose**—The Village Council is considering the installation of electric-operated pumping equipment in connection with proposed extensions in the waterworks. L. H. Whitman is village clerk.

**N. J., Newark**—The Alderney Dairy Co., 20 Bridge Street, has filed plans for the construction of a power house at its local dairy plant to cost about $55,000. William E. Lehman, 738 Broad Street, is architect.

**N. J., Newark**—The Board of City Commissioners, City Hall, has authorized the installation of additional equipment at the power house and water supply plant at the city hospital, Fairmount Avenue, to cost $70,000.

**N. J., Pleasantville**—The Peerless Plush Mfg. Co., 71 Franklin Street, Paterson, N. J., has engaged Russell G. Cory, 30 Church Street, New York, engineer, to prepare plans for its local textile mill and steam power plant, estimated to cost $250,000, for which bids will soon be asked.

**N. Y., Buffalo**—The Commissioner of Public Works, Municipal Building, will receive bids until Feb. 28, for centrifugal pumps and motors, electric switchboard and switchboard apparatus for the new low-lift pumping station at the filtration plant. Fuller & McClintock, 170 Broadway, New York, are consulting engineers.

**N. Y., New York**—The Department of Plant and Structures, Municipal Building, plans for the installation of a steam power plant, ice-manufacturing and refrigerating plant at the proposed seven-story municipal market to be constructed at Cromwell Avenue and the Harlem River, estimated to cost $7,500,000.

**N. Y., Niagara Falls**—The Niagara Falls Power Co. has arranged an expansion program for the present year, to include an increase in hydro-electric generating plants of about 140,000 hp.

**N. Y., Rochester**—The Rochester Gas & Electric Co., has arranged an extension and improvement program for the present year, to include the completion of a 50,000 hp. steam-operated electric generating plant.

**N. Y., Syracuse**—The Board of Trustees, St. Joseph's Hospital, Louis Will, 714 Bridge Street, chairman, has authorized plans for the construction of a power house at the new institutional building at Union Park and Prospect Avenues, to cost about $600,000. Gaggin & Gaggin, University Building, are architects.

**N. C., Charlotte**—The Yarbrough & Bellinger Co. has plans under way for the construction of three electrically-operated ice-manufacturing plants on local sites, with total capacity of 250 tons per day. Y. A. Yarbrough is president.

**N. C., Forest City**—The Forest City Oil Mill Co., has inquiries out for equipment for a proposed local raw-water ice-manufacturing plant. J. E. Lipscomb is head.

**N. C., Morganton**—The Building Committee, State Hospital, will receive bids until Feb. 23 for two direct-connected, engine-driven, electric generators, with exciters, switchboard, etc.; power station piping and auxiliaries; motors and other miscellaneous equipment, and settings for four boilers, for the power house at the institution. Wiley & Wilson, Lynchburg, Va., are consulting engineers. Dr. John McCampbell is superintendent.

**N. C., Walnut Cove**—The City Council, H. R. McPherson, city clerk, will soon award contracts for equipment for its proposed municipal electric power plant. An award for the building and dam has been made to M. E. Jones, Walnut Cove.

**N. C., Waynesville**—The Pigeon River Power Co., is perfecting plans for the early construction of a hydro-electric power plant on the Pigeon River, with inital capacity of 60,000 hp., for which a Federal permit has been granted. F. R. Weller, Mills Building, Washington, D. C., is consulting engineer.

**N. D., Bismarck**—The North Dakota State Game and Fish Commission has tentative plans for the purchase of a pumping engine and auxiliary equipment for installation at a plant near Fish Lake, Rolette County.

**N. D., Richardton**—The Lignite Coal & By-Products Co., Minneapolis, Minn., K. A. Loven, vice-president and general manager, plans for the construction of a power house at its proposed local lignite works, estimated to cost $350,000. The initial unit is expected to cost $130,000.

**Ohio, McDermott**—The McDermott Stone Co. has tentative plans for the construction of a power house at its proposed local plant, replacing a works recently destroyed by fire, estimated to cost $200,000.

**Ohio, Toledo**—The National Ice Cream Co., will install refrigerating and ice-making machinery in its proposed new plant on Michigan Street, estimated to cost $100,000, on which work will be commenced at once.

**Ohio, Woodville**—The Bruns Hydrated Lime Co., recently organized, is reported to be planning for the construction of a steam power plant at its proposed local mill, estimated to cost $200,000, with equipment. J. W. Bruns, Woodville, is president.

**Okla., Nowata**—The Common Council has commissioned the Benham Engineering Co., Gumbel Building, Kansas City, Mo., to prepare plans for the proposed extensions and improvements in the waterworks, to include electric-operated pumping machinery. Bonds for $75,000 have been voted.

**Pa., Danville**—The Board of Trustees, State Hospital, Fred M. Sprout, chairman of building committee, has had plans completed for a power house at the institution, to cost about $75,000. F. Arthur Rianhard, Masonic Temple, Williamsport, Pa., is architect.

**Pa., Lansford**—The Panther Valley Water Co., plans for the installation of electric-operated pumping machinery in connection with its proposed water supply system from Still Creek, estimated to cost $1,200,000. The company is operated by the Lehigh Coal & Navigation Co., 437 Chestnut Street, Philadelphia.

**Pa., McKeesport**—The City Council plans for the installation of electric-operated pumping machinery in connection with proposed extensions and betterments in the municipal waterworks, for which a bond issue of $233,000 will soon be sold.

**Pa., Sunbury**—The Sal-Co-Lene Co., Three Rivers, Mich., plans for the construction of a power house at its proposed local branch plant, estimated to cost $400,000, with equipment. Dr. F. K. Moyer is president.

**R. I., Providence**—The Sun Oil Co., Lancaster and Powelton Avenues, Philadelphia, Pa., will build a boiler plant at its local oil storage and distributing works, on which work will be commenced at once.

**S. C., Easley**—The City Council is considering the installation of electric-operated pumping machinery in connection with water supply and sewerage system extensions. Preliminary surveys are being made by Horwood Beebe, Spartanburg, S. C., engineer.

**Tenn., Ashwood**—The Ridley Phosphate Co., Mount Pleasant, Tenn., has preliminary plans for the construction of a steam power plant at its local phosphate works, on which erection will soon commence. C. W. Alexander is secretary. I. L. Chadwell is engineer in charge of construction.

**Tenn., Lewisburg**—The Common Council plans for the installation of an electric-operated pumping plant in connection with the proposed waterworks system, for which bonds for $150,000 have been sold.

**Tenn., Memphis**—The Southern Hotel Co., will install a power plant in its proposed local twelve-story hotel building, 170 x 325 ft., estimated to cost $3,000,000, for which foundations will soon be laid. The power installation will consist of three 200 kw. generators, boilers and auxiliary equipment. Walter W. Ahlschlager, 65 East Huron Street, Chicago, Ill., is architect.

**Tex., Brady**—The Mayhew Produce Co., has preliminary plans under way for the construction of a new ice-manufacturing and cold storage plant, and proposes to take bids for equipment at an early date.

**Tex., Brownwood**—The Gulf, Colorado & Santa Fe Railway Co. plans for the construction of a steam power plant at its proposed rock crushing plant in the Hall Mountain section, on site recently acquired. F. Merritt, Galveston, Tex., is chief engineer.

**Tex., Columbus**—O. A. Zumwalt, Columbus, and associates, are perfecting plans for the organization of a company to construct and operate a hydro-electric power plant on the Colorado River for local industrial service. Dr. A. S. McDaniels, San Antonio, Tex., is interested in the project.

**Tex., Dallas**—The Continental Gin Co., 3701 Race Street, is considering the installation of a steam power plant at its new local two-story cotton gin, on which work will soon be commenced.

**Tex., Dallas**—The Poultry Producers' Exchange of the Texas Farm Bureau, has tentative plans under consideration for the construction of a central cold storage plant, with a number of system units in different localities, to cost about $325,000. G. T. Platt is general manager.

**Tex., Jacksonville**—The Texas & New Orleans Railroad Co., a subsidiary of the Southern Pacific Railroad Co., Houston, Tex., is considering plans for the erection of a power house at its proposed local shops, estimated to cost $200,000.

**Tex., Mart**—The Common Council has commissioned Koch & Fowler, Dallas, Tex., engineers, to prepare plans for the proposed waterworks plant and system, to include the installation of electric-operated pumping machinery. It is expected to ask bids by the close of the month. Bonds for $150,000, have been voted.

**Tex., Ranger**—The City Council has engaged the Elrod Engineering Co., Dallas, Tex., to prepare plans for proposed extensions and improvements in the municipal waterworks, for which bonds for $150,000 are available. It is proposed to install electric-operated pumping machinery. R. H. Hodges is mayor.

**Tex., Waco**—The Big Four Ice Co. has authorized plans for the erection of a new refrigerating plant at Twelfth and Columbus Streets, with initial daily capacity of 30 tons.

**Va., Charlottesville**—The City Council has tentative plans for the installation of electric-operated pumping machinery in connection with proposed extensions and improvements in the waterworks, for which a bond issue of $500,000 has been sold.

**Va., Galax**—The Galax Knitting Co., High Point, N. C. plans for the construction of a steam-operated electric power plant at its proposed local textile mill. C. C. Robbins is general manager.

**Wash., Kelso**—The American By-Products Co., Donegan Building, Vancouver, Wash., plans for the construction of a power plant at its proposed local lignite works and byproducts plant, to cost in excess of $350,000. Henry C. Prudhomme is secretary and general manager.

**Wash., Seattle**—The Puget Sound Power & Light Co. is having plans prepared for the construction of a hydro-electric generating plant on the Sultan River with initial capacity of 4,000 kw., to cost approximately $500,000.

**Wash., Spokane**—The Home Sash & Mfg. Co. plans for the construction of a boiler plant at its proposed local mill at Mission and Haven Streets, to cost about $85,000. The company also proposes to construct other mills at a later date.

**Wis., Milwaukee**—The Pyro Mfg. Co., 3220 Vliet Street, is planning for the rebuilding of the portion of its boiler house, recently destroyed by fire.

**Wis., New Holstein**—The City Council is considering the installation of electric-operated pumping machinery in connection with a waterworks and sewerage system, for which bonds for $96,000 have been sold.

**Wis., Phillips**—The City Council will receive bids until Feb. 21, for pumping equipment for a municipal plant, including one reciprocating unit of 300 g.p.m. capacity, with motor drive; one centrifugal pump, 1,000 g.p.m. capacity, motor drive, and gasoline engine stand-by, with electrical and auxiliary equipment. Also, for a steel storage tank and tower. Druar & Milinowski, 500 Globe Building, St. Paul Minn., are consulting engineers. Carl F. Scheel is city clerk.